Integrated Chemical and Biological Defense Research, Development and Acquisition Plan

CHEMICAL & BIOLOGICAL POINT DETECTION
DECONTAMINATION
INFORMATION SYSTEMS

April 2003

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Integrated Chemical and Biological Defense Research, Development and Acquisition Plan: Chem-Bio Point Detection, Decontamination and Information Systems Technology Areas

Introduction

This report is the third annual edition of a series of interagency coordination documents that serve a dual purpose. First, they fulfill Counterproliferation Program Review Committee (CPRC) and congressional coordination and reporting requirements[1] for the Department of Defense (DoD) and the Department of Energy (DOE) in the area of chemical and biological defense (CBD) research,[2] development and acquisition (RDA). The first CBD RDA report published in April 2000[3] explained the rationale for and genesis of interagency coordination via the CPRC-chartered CBD Focus Group and the roles and responsibilities of DoD and DOE and other agencies.

The *Integrated Chemical and Biological Defense Program Research, Development and Acquisition Plan for the Departments of Defense and Energy: Bio Point Detection,* published in March 2001, presented the first technology area-focused roadmap. The narrower and more detailed scope of the roadmap reports serves the second and equally important purpose of the effort. The technology area roadmaps are "living" documents intended to facilitate coordination and cooperation between DOE and DoD at both the high level of national policy and planning and at the working level in the technology focus areas. They depict participating organization R&D programs and plans for testing and transitioning technologies into the acquisition process. Program data comes from existing planning documents in many cases; however, it should be noted that appearance within the roadmap does not imply funding commitments. Rather, the integration of these efforts into a single planning document represents a significant step toward a more formal, unified, long-term investment strategy.

The intent of the roadmaps is to allow agency leaders to have visibility across current and planned RDA efforts to avoid duplication of effort and to identify possible synergies and relevant research performed by their partner agencies. In addition, a key objective of the CBD RDA Focus Group[4] is to provide useful information to Principal Investigators (PIs) and Program Managers (PMs) as well as to inform and enhance interaction among R&D scientists. The Bio Point Detection effort resulted in a general annual process for developing and then updating the technology areas. An annual report to the CPRC will include the updated technology area roadmaps for all areas covered; eventually a single Integrated Plan will cover all areas listed in Figure 1.

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[1] See Appendix D for the congressional language establishing these requirements.

[2] The DOE Chemical Biological National Security Program has been transferred to the Department of Homeland Security. Since this report covers activity through FY02, we refer to the program herein as DOE CBNP.

[3] Integrated Chemical and Biological Defense Research, Development and Acquisition Plan for the Departments of Defense and Energy, Counterproliferation Program Review Committee, April 2000.

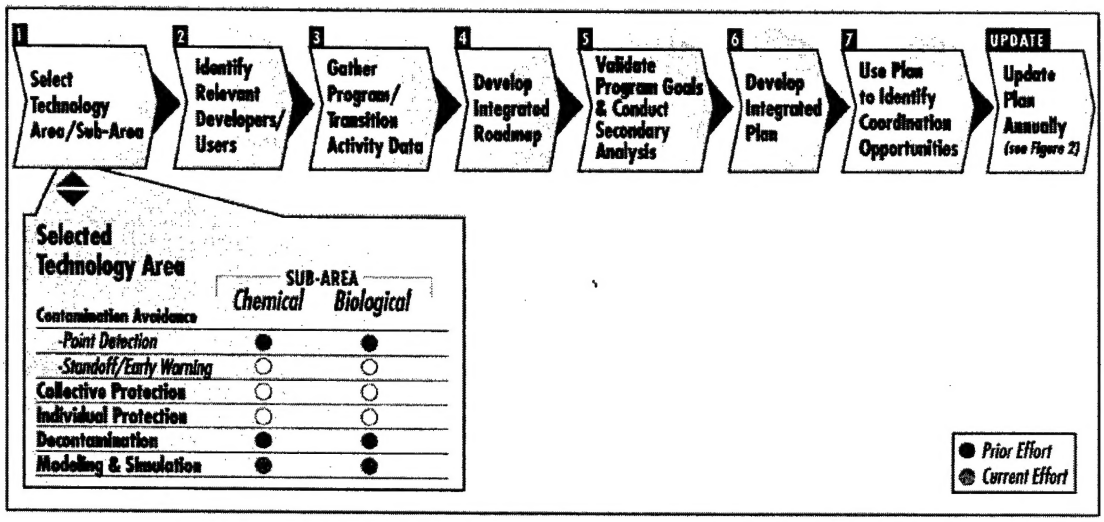
[4] The Focus Group includes decision-makers and area experts from CBD, DARPA and CBNP.

Previous roadmaps were well received by the CPRC and the Deputy Assistant to the Secretary of Defense for Chemical and Biological Defense. As a result, the Focus Group was directed to:

- Expand the number of technology areas covered
- Expand DoD/DOE roadmapping process to include a broader set of organizations

Last year's report included both an expanded chem-bio point detection roadmap and the decontamination roadmap. This year we have added the beginnings of a modeling and simulation roadmap (see Figure 1 for progress to date). In addition, the Technical Support Working Group (TSWG), the Department of Justice (DOJ), the Defense Threat Reduction Agency (DTRA), the Missile Defense Agency (MDA), and the Environmental Protection Agency (EPA) provided input to this year's report. Intelligence community representatives have participated in Focus Group meetings. Coordination has begun with the Nonproliferation and Arms Control Technology Working Group (NPAC TWG).

Figure 1. Technology Roadmap Development Process & Progress To Date



Methodology

The integration template employed here has two essential elements:

- A format for an integrated technology area Roadmap
- A repeatable process by which the Roadmap is first developed and then annually reviewed and updated

As additional technology areas are addressed, the template and the development/update process will be repeatedly tested and improved, culminating in a comprehensive Integrated Plan.

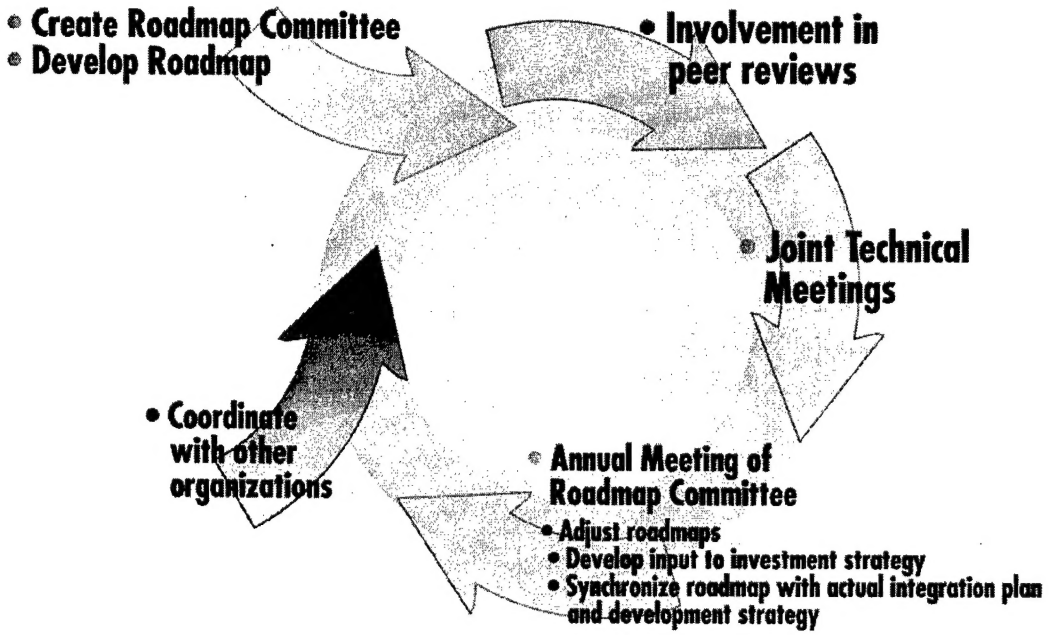
Selection of a technology area and identification of stakeholders (developers and users) are the first steps in the roadmap development process. The next step is to determine what specific data is relevant to increased interagency RDA transparency. This data includes:

- Timelines for anticipated acquisitions, and major thrust areas
- Top-level guidance (Joint Future Operational Capabilities (JFOCs), Areas for Capability Enhancements (ACEs))
- Testing and demonstration activities and key events (*e.g.*, Advanced Technology Demonstrations/Advanced Concept Technology Demonstrations (ATDs/ACTDs), Joint Field Trails (JFTs), Domestic Demonstration and Application Programs (DDAPs))
- Technology area R&D programs: timelines and key milestones, including participation in testing and demonstration activities

By showing R&D program timelines, transition timelines and testing activities in a single graphic, the roadmap provides a panoramic look ahead for a given technology area. The above data must be gathered from each agency's existing planning documents, program managers (PMs) and principal investigators (PIs) in order to complete the roadmap.

Figure 2 depicts the annual roadmap development and update process; note that there are no set timelines, with the exception of the annual meeting of the Roadmap Committee. This is because, although the process is applicable to all technology area roadmaps, it will involve interaction with some different sets of developers and users for each, so the timing of annual cycles may differ. Ideally, all roadmap updates should be completed in time to influence development of investment strategies.

Figure 2. Annual Integration Process and Roadmap Update Cycle



The process steps depicted in Figure 2 and briefly described below apply to all technology area roadmaps, but examples and details are based on the bio point detection

roadmapping process. It should be noted that the process is still under development and will continue to be tested and modified as technology area coverage and interagency participation is broadened.

The process includes the following steps:

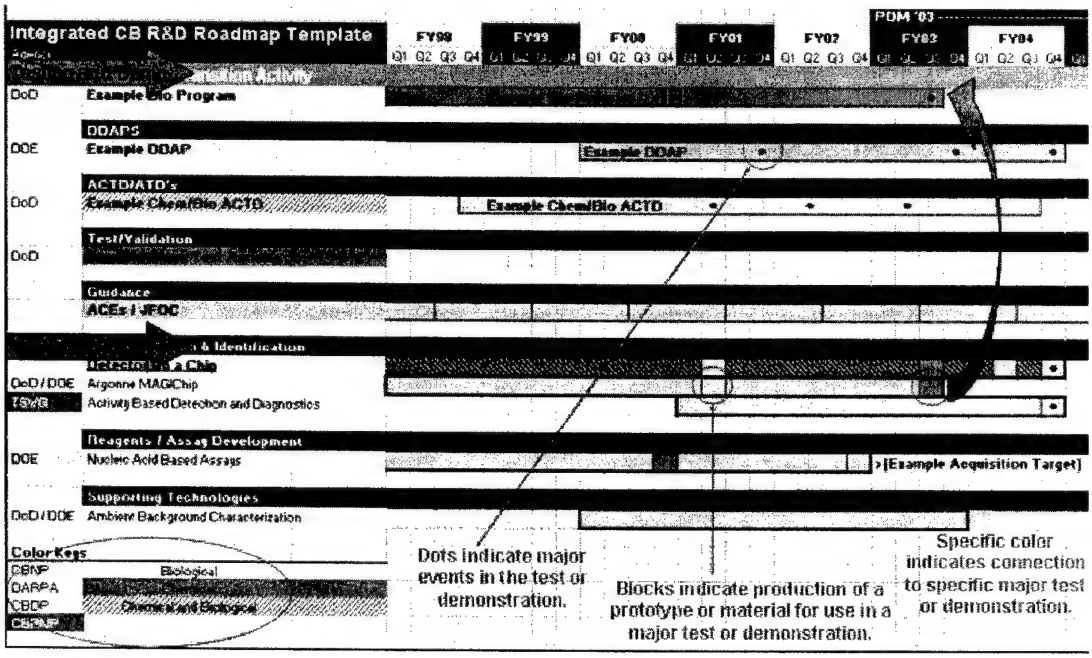
- Establishment of the Roadmap Committees, which are technology area sub-committees of the Focus Group; this occurs only once, during overall process development. The Focus Group identifies Roadmap Committee members for each technology area and has done so for bio point detection. Roadmap committees include, at a minimum, one representative from each participating organization.
- Establishment of the initial technology area roadmaps, once for each technology area, by the designated Roadmap Committees. These initial roadmaps are then reviewed and adjusted annually.
- Cross-organizational involvement in peer reviews, to facilitate identification of any potential duplication of effort or opportunities to cooperate and leverage synergies across programs and demonstrations. This is an ongoing activity, but should acquire new emphasis as the roadmapping process proceeds. This cross-organizational involvement is required to deconflict planning and develop shared expectations across the technology area community.
- Regular joint detection meetings at the PI level to ensure continuous progress on deconfliction and integration. These meetings must occur at least annually for each technology area Roadmap Committee to review and update the roadmaps in time for the annual spring meeting of the Focus Group. Each Committee has the latitude to select an opportune technical conference around which to schedule an update meeting.
- Special focus technology meetings that bring in key members of the user-developer community, when deemed appropriate by the detection PIs, the technology area Roadmap Committee, or the Focus Group. Such meetings may occur if a developing technology is under consideration for inclusion in a transition testing or demonstration activity, for example.
- Coordination with other organizations, including the intelligence community (IC) overall and specific organizations, such as Measurement and Signature Intelligence (MASINT), and other CPRC member organizations.
- The annual roadmap development, review and update process will culminate in a spring meeting of the Focus Group to review progress on all technology area-specific CBD RDA plans; adjust the roadmaps as needed; and develop investment strategies. It is critical that this meeting take place in the spring, in time to affect the POM update cycle.

The Roadmap Template

The first product defined in the above methodology is a template for the Technology Area Roadmaps. The intent of the Roadmap template is to provide a tool for depicting DoD and DOE R&D programs and the means and timing of their integration into Testing, Demonstration and Acquisition activities in order to facilitate cross-organizational awareness and cooperation. Such cooperation will assist in eliminating unnecessary duplication of DoD/DOE R&D efforts as well as provide a means for productive interagency leveraging.

Figure 3 shows the general Roadmap template, which is separated into two main sections. The top section consists of Acquisition/Transition Activities, whereas the lower section comprises R&D Programs in a given technology sub-area. Funding and executing entities responsible for these activities and programs are listed in the column on the far left. The Acquisition and Transition Activities listed are exercises/events that provide technology insertion points for Sensor/System program deliverables. Acquisition/Transition Activities include formal acquisition programs, demonstration, testing programs, and guidance documents.

Figure 3. The General Roadmap Template



Each technology area Roadmap is color coded for clarity and can be viewed at the summary level (aggregated technology sub-area groupings) or at the individual program level:

- The far left column lists the agency (DOE, DoD, TSWG) under which the research effort listed in the next column to the right falls. The color coding in the far left column designates the division, program, or sub-group within each of these agencies that owns the research effort. In this example, CBNP (DOE) activity/program titles on the left are shaded in orange, DARPA (DoD) activities are light blue, and CBRNP (TSWG) activities are purple. CBDP (DoD) activity/program titles are not shaded.
- The timeline bars associated with each Acquisition/Transition Activity are also uniquely colored. Black and white dots are placed within these timeline bars to denote a major test

or demonstration will take place in a specific activity. Black dots designate "hard" milestones, those at which a firmly scheduled activity or event occurs. White dots represent "soft" milestones—timing goals rather than firm events.

- For each group of similar programs (*e.g.*, Detector on a Chip), a summary bar extends across the timeline in black/gray diagonal shading. The bar includes all milestone activities for the programs within the group, in this case Argonne MAGIChip and Activity Based Detection and Diagnostics. As the number of programs covered in the point detection roadmap grows, these bars will allow the presentation of a summary roadmap, by technology group, on a single page. Program-level roadmaps can be included behind the "big picture" summary.
- R&D program involvement in an Acquisition/Transition activity is shown on the program timeline bars. A block in color denoting the Acquisition/Transition activity is inserted to depict the specific test/demonstration and time period that an R&D deliverable will be tested or demonstrated. A black vertical border at the first year covered by the Roadmap denotes a new start; programs without the border line were ongoing prior to the time period covered by the Roadmap.
- At the end of a program timeline, the transition target is listed; in some cases, this will be commercial.

Technology Area Roadmaps and Analyses

This report includes the chem-bio point detection roadmap, the decontamination roadmap, and the new information systems roadmap. In addition to the graphic roadmaps, the report includes the following information, to be included in each annual report edition:

- Summaries of acquisition and transition activities are provided for both roadmaps. Transition/Acquisition and Project/Program details can be found in Appendix A for chem-bio point detection, in Appendix B for decontamination, and Appendix C for information systems.
- Current programs and projects are grouped into key technology sub-areas in both roadmaps; the rationales for the classification and key characteristics of each grouping are discussed.
- The roadmap report Findings sections, which are separate for each technology area covered, discuss the impact of the cooperative planning undertaken as a result of the roadmapping initiative. Both successes and challenges are identified.
- Each annual edition generally includes at least one redundancy analysis of a selected research approach within a technology area covered by the report. This is summarized in Figure 4, which will be updated annually. The purpose of this analysis is to ensure there is no unnecessary duplication of effort among the funded programs within the technology area. Last year's report included an analysis of ongoing oxidative chemistry research programs; that analysis is revisited this year.

Figure 4. Progress on Technology Area Roadmaps and Redundancy Analyses

Report Technology Areas	Year	Redundancy Analysis
Biological point detection	2001	Mass spectrometry
Chemical and biological point detection and decontamination	2002	Peroxy-based oxidative decontamination approaches
Chemical and biological point detection, decontamination and information systems	2003	Vaporous Hydrogen Peroxide

The Chem-Bio Point Detection Roadmap

The Chem-Bio Point Detection Roadmap is shown in Figure 5 on the following two pages. The Roadmap covers relevant Acquisition/Transition activities and R&D programs from FY01 through FY12.

Figure 5. The Chem-Bio Point Detection Roadmap

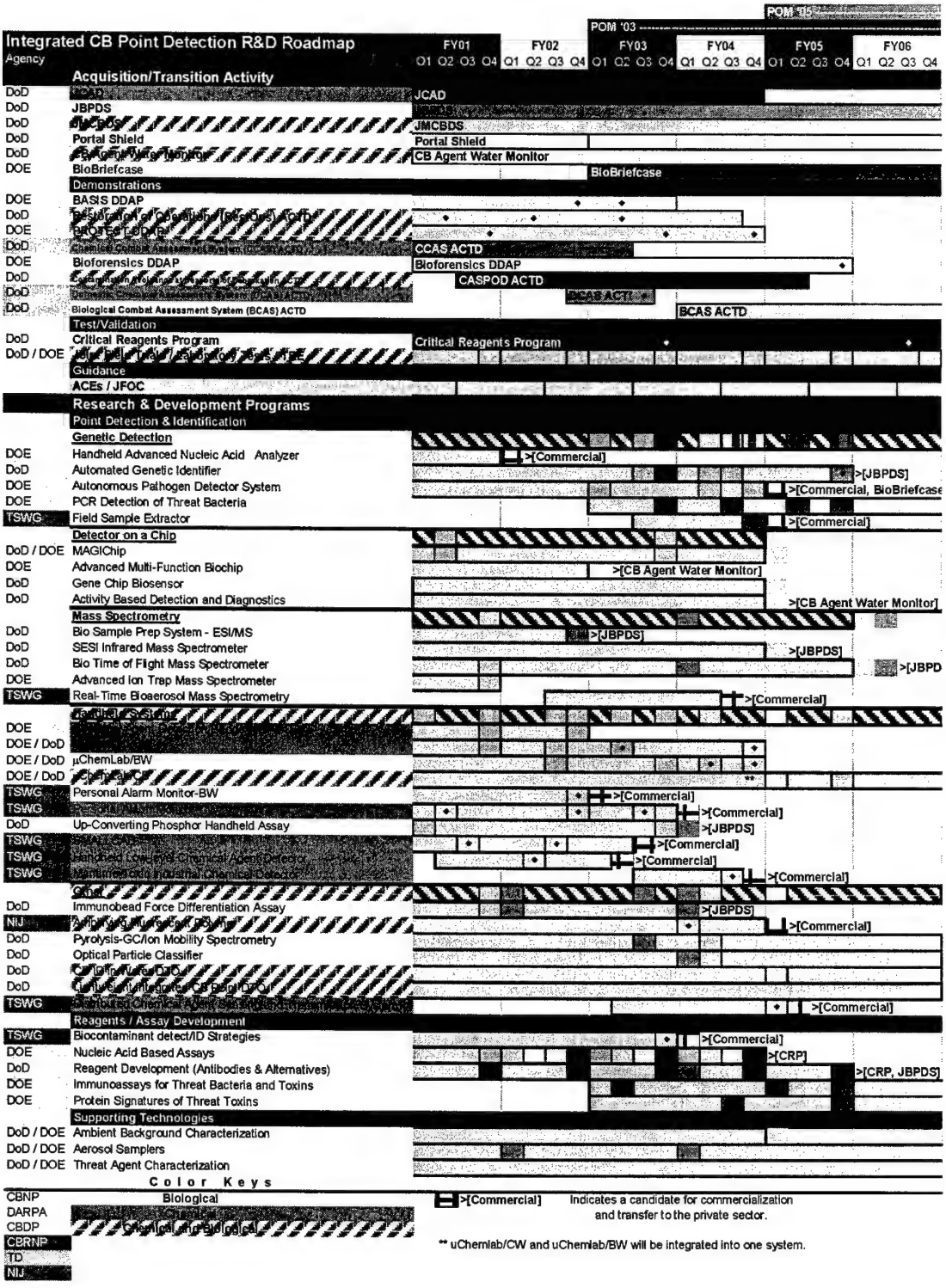
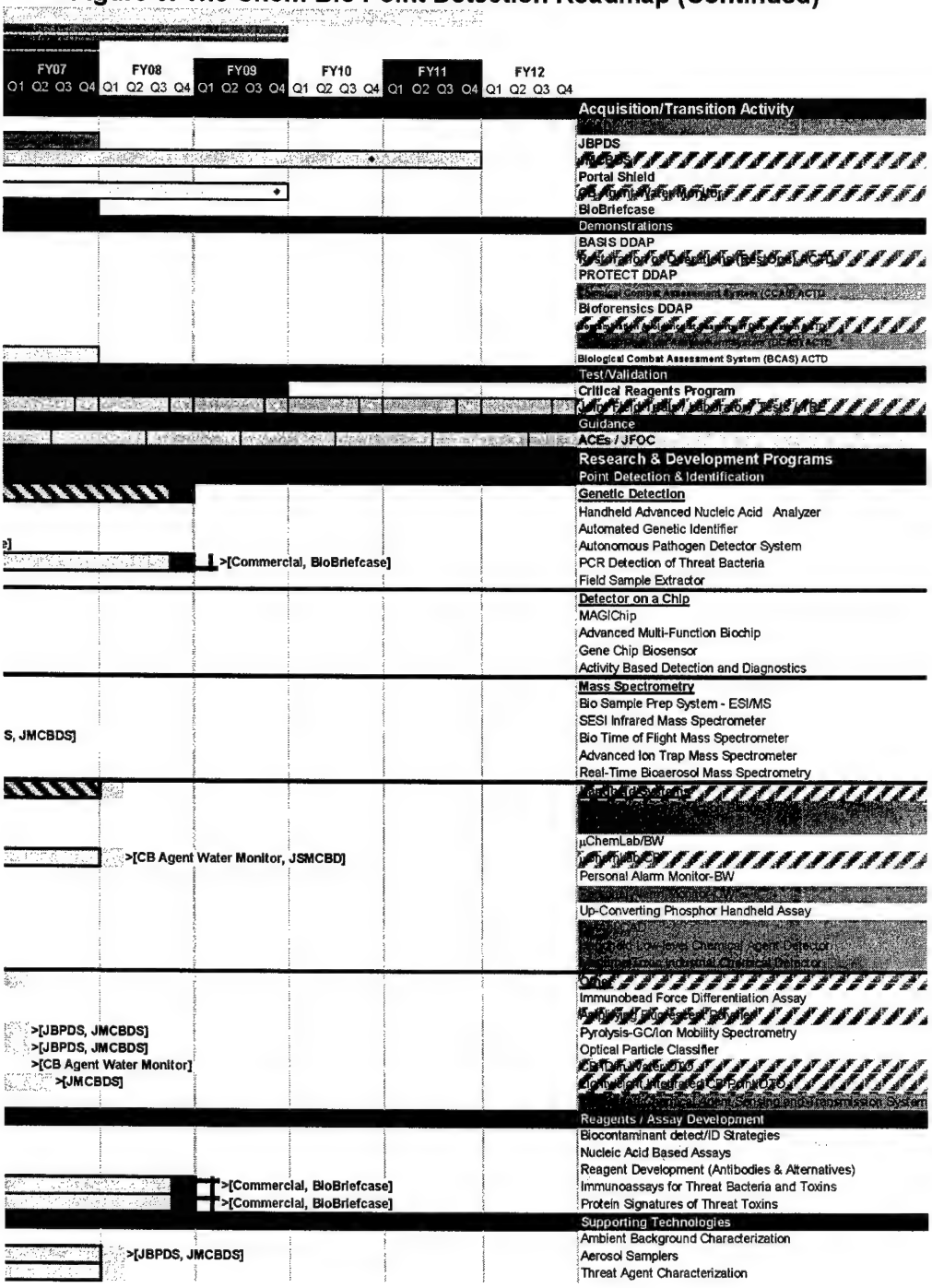


Figure 5. The Chem-Bio Point Detection Roadmap (Continued)



Acquisition/Transition Activities Involving Chemical and Biological Detection Technologies

The transition and acquisition activities to which DoD and DOE CB point detection R&D programs make significant contributions include four DoD programs, three DOE Domestic Demonstration and Application Programs (DDAPs), five DoD Advanced Concept Technology Demonstrations (ACTDs), and several types of testing and validation programs.

The DoD transition and acquisition activities, as well as the supporting R&D programs, contribute to requirements developed in two key pieces of guidance:

- The Joint Future Operational Capabilities (JFOCs) list developed by the Joint Services
- The prioritized CPRC Areas for Capability Enhancement (ACEs)

Specifically, activities and programs included in the CB Point Detection Roadmap support the development of warfighting capabilities for DoD ACE Priority 2: Detection, Identification, Characterization, Location, Prediction and Warning of CW and BW agents.

Chemical and Biological Detection: Current Programs and Projects

Sensor/System R&D programs include Chemical and Biological Point Detection and Identification, Reagents/Assay Development, and Supporting Technologies. Biological Point Detection and Identification Programs are further subdivided into major activity areas: Genetic Detection, Detector on a Chip, Mass Spectrometry, handheld systems, and other programs that have not yet been categorized. At this time, these uncategorized programs are currently grouped in the "Other" Technology group. A detailed description of these activities and programs can be found in Appendix A.

In developing the roadmap, the Focus Group identified several "like" biological R&D programs that have been grouped together. While three of these groups (Genetic, Chip, Mass Spec.) are based on common technology platforms, program approaches explore different ways of applying the underlying technology. Figure 6 provides a summary overview of the technology groupings and shared technology platforms. The table also includes supporting technologies that will contribute to the other more mature groups once they are better defined. Each program is identified as bio-focused (B), chem-focused (C) or as a program with both chemical and biological applications (CB).

Figure 6. Sensor/System R&D Technology Groupings

Technology Group	Programs		Shared Technology Platform
Detection and Identification			
Genetic Detection	• HANAA	B	PCR for genetic detection of bacterial and viral agents
	• Auto Genetic ID	B	
	• APDS	B	
	• PCR DTB	B	
	• Field Sample Extractor	B	
Detector on a Chip	• Argonne MAGIChip	B	Microchip platform for detection
	• Advanced Multi-function Biochip	B	
	• Gene Chip Biosensor	B	
	• Activity Based Detection and Diagnostics	B	
Mass Spectrometry	• BSPS–ESI/MS	B	Mass spectroscopy methodologies for sample handling/analysis
	• SESI IR MS	B	
	• Bio–ToF MS	B	
	• Advance Ion Trap MS	B	
	• Real Time Bio MS	B	
Handheld Systems	• CADB	C	Systems optimized for handheld use
	• µChemLab/CW	C	
	• µChemLab/BW	B	
	• µChemLab/CB	CB	
	• Personal Alarm Monitor–BW	B	
	• Personal Alarm Monitor–CW	C	
	• UCPHHA	B	
	• SMALLCAD	C	
	• Handheld Low-level CAD	C	
	• Maritime TICD	C	
Other	• Immunobead Force Differentiation Assay	B	N/A—each platform is unique
	• Amplifying Fluorescent Polymer	CB	
	• Pyrolysis-GC/Ion Mobility Spectrometry	B	
	• Optical Particle Classifier	B	
	• CB ID in Water	CB	
	• Integrated CB Point	CB	
	• DCASTS	C	
Reagent/Assay Development			
	• Biocontaminant Detect/ID Strategies	B	Goal of programs is shared, but the nucleic acid-based program differs from the antibody programs
	• Nucleic Acid-Based Assays	B	
	• Reagent Development (antibodies & alternatives)	B	
	• Immunoassays	B	
	• Protein Signatures	B	
Supporting Technologies			
	• Ambient Background Characterization	B	Immature technologies not yet fully defined; will eventually contribute to the bio point detection technologies listed above
	• Aerosol Sampler Development	B	
	• Threat Agent Characterization	B	

Findings

Cooperative Planning

The integration effort has also had an early influence on sensor system participation in planned acquisition/transition testing. Clearly, the integrated chem-bio point detection roadmap seen above demonstrates a reasonably integrated effort. The current roadmap represents substantial progress in cooperative planning over the initial roadmap that was generated in the early stages of the integration effort. For example, comparison of the first and current versions shows a significant increase in the number of interagency integration opportunities that have been identified and will now be exploited for sensor system R&D items. This increase is mainly due to regular Focus Group meetings. Increased participation has included the Technology Support Working Group (TSWG), and efforts are underway to reach out to the Nonproliferation and Arms Control Technology Working Group (NPAC TWG) to integrate their Real-Time PCR Identification into the Roadmap.

The roadmap has also helped Focus Group members to identify an important planning gap: it clearly shows a significant reduction in planned transition and acquisition activity after FY04. This means that several nascent but mission-critical technologies may not make it into the hands of the user if suitable transition opportunities are not identified to bring them to the field. The purpose of the Integrated Plan is to ensure that planning for these technologies is based on a strategic vision with a horizon beyond current POM or budget cycles, though detailed funding requirements will not be articulated until a given activity is within the budgetary timeline. Regular Focus Group meetings must therefore continue, in accordance with the new annual process articulated above, in order to articulate proactively the R&D community's requirements for transitioning critical chemical and biological detection technologies to the field, thus buttressing efforts to assure adequate and timely funding.

The Decontamination Roadmap

The summary level Decontamination Roadmap is shown in Figure 7 on the following two pages. The Roadmap covers relevant Acquisition/Transition activities and R&D programs from FY01 through FY12.

Figure 7. The Decontamination Roadmap

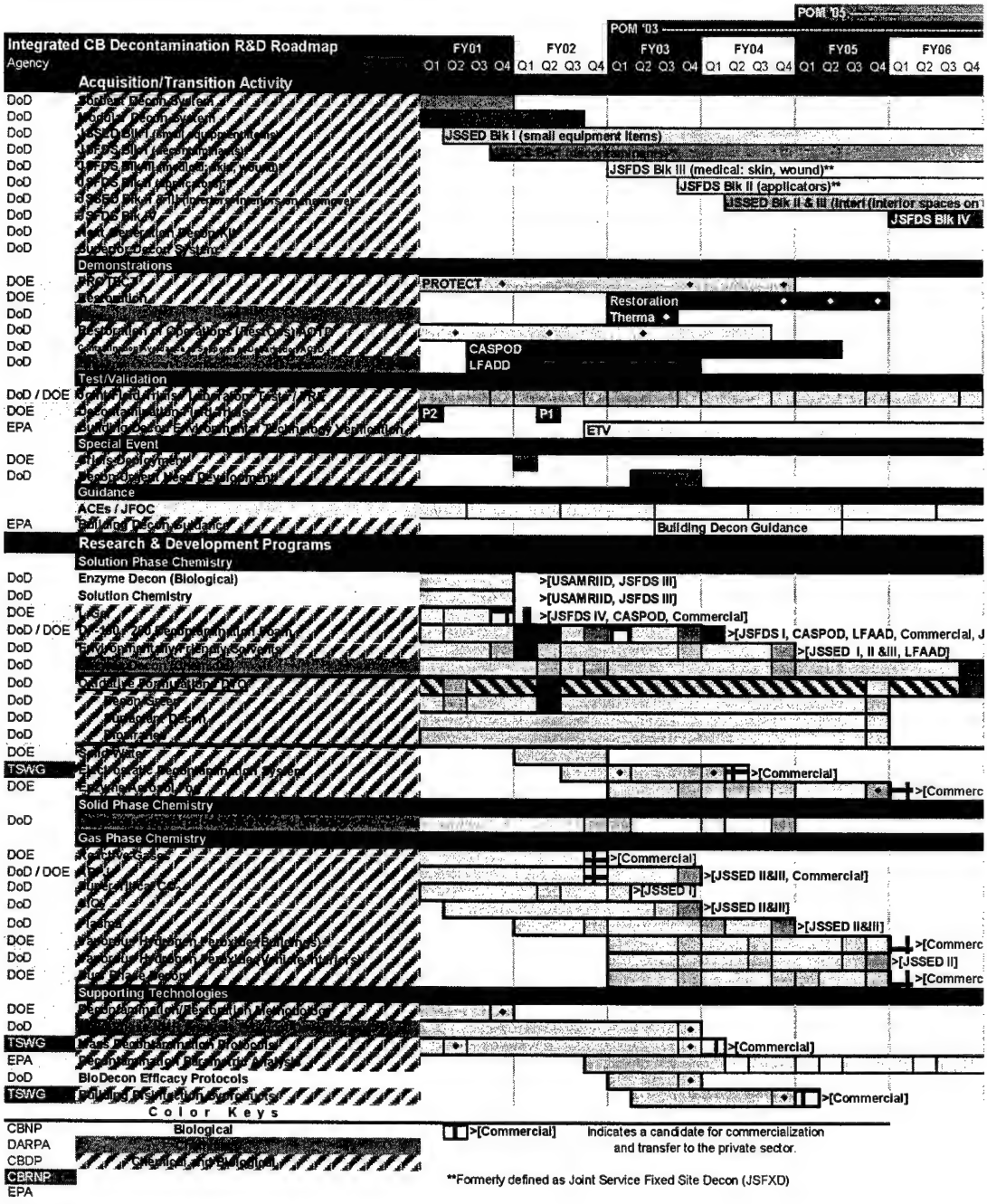
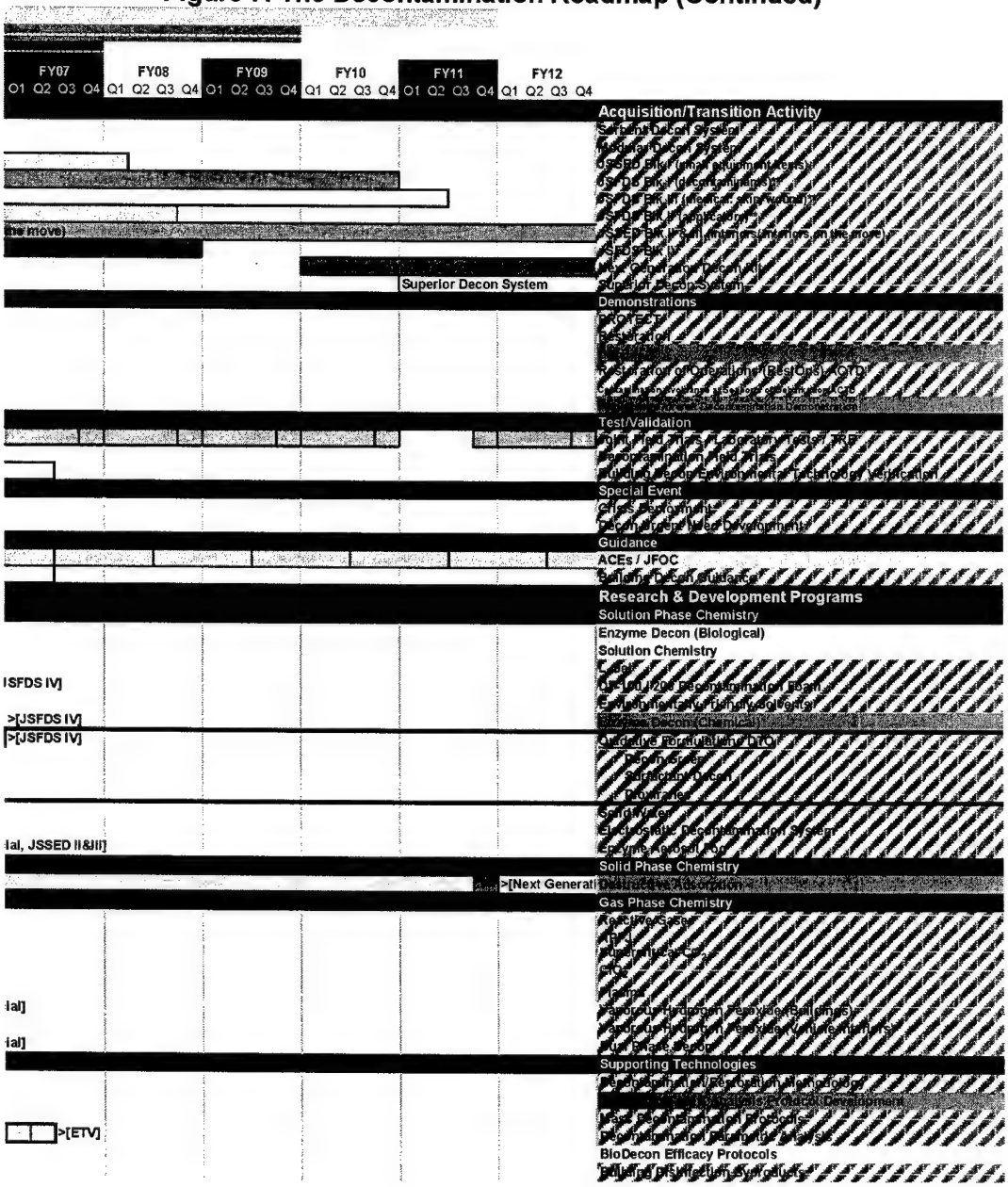


Figure 7. The Decontamination Roadmap (Continued)



Acquisition/Transition Activities Involving Decontamination Technologies

The transition and acquisition activities to which DoD and DOE CB Decontamination R&D programs make significant contributions include six DoD programs, two DDAP, three ACTD and several types of testing and validation programs. The DoD activities, as well as the supporting R&D programs, contribute to requirements developed in two key pieces of guidance:

- The Joint Future Operational Capabilities (JFOCs) list developed by the Joint Services
- The prioritized CPRC Areas for Capability Enhancement (ACEs)

Specifically, activities and programs in the CB Decontamination Roadmap support the development of warfighting capabilities for DoD ACE Priority 3: Enable sustained operations in a WMD environment through decontamination, and individual and collective protection.

Decontamination: Current Programs and Projects

Decontamination R&D programs are divided into four major technology areas: Solution Phase Chemistry, Solid Phase Chemistry, Gas Phase Chemistry and Supporting Technologies. Figure 8 provides a summary overview of the technology groupings and shared technology characteristics. Shared technology characteristics identified by the Roadmap Committee fall into four major areas: Oxidative Chemistry, Enzyme-based, Sensitive Equipment and Methodology Verification. Although each area identifies similarities in technologies, the approach used by each research effort is unique. A detailed description of these activities and programs can be found in Appendix B.

Figure 8. Decontamination Technology Groupings

Technology Group	Programs		Shared Technology Characteristics
Solution Phase Chemistry			
	• L–gel	CB	Oxidative Chemistry
	• DF–100 (Sandia Foam)	CB	
	• Environmentally Friendly Solvents	CB	
	• Decon Green	CB	
	• Surfactant Based Decon Solution	CB	
	• Dioxiranes	CB	
	• DARPA Solution Chemistry	B	to be provided
	• Enzyme Decon (Chemical) CBDP	C	Enzyme-based
	• Enzyme Decon (Biological) DARPA	B	
	• Electrostatic Decontamination System	CB	Photoactivated system
Solid Phase Chemistry			
	• Destructive Adsorption	C	Reactive nanoparticles
Gas Phase Chemistry			
	• Reactive Gases	CB	Sensitive Equipment
	• APPJ	CB	
	• Supercritical CO_2	CB	
	• ClO_2	CB	
	• Plasma	CB	
	• Vaporous Hydrogen Peroxide (buildings)	CB	
	• Vaporous Hydrogen Peroxide (vehicles)	CB	
	• Dual Phase Decon	CB	
Supporting Technologies			
	• Decon/Restoration Methodology	CB	Methodology Verification
	• Solid Phase NMR Protocol	C	
	• Mass Decon Protocols	CB	
	• Decon Parametric Analysis	CB	
	• BioDecon Efficacy Protocols	B	
	• Building Disinfection Byproducts	CB	

Findings

Cooperative Planning

The newest area of collaboration between DoD and DOE is with the use of vaporized hydrogen peroxide (VHP) as a chemical and biological agent decontaminant. Although these are separate efforts within the two departments and will be used in different scenarios, DoD and DOE are each aware of the goals and objectives of the other program, and leveraging opportunities have been identified. Close cooperation is planned at the program and research levels in a manner similar to that seen with the other peroxy-based programs. In addition, the EPA is interested in collaborating and leveraging since VHP was identified as a potential restoration technology within the EPA Safe Building Program.

DoD

In FY03, Congress appropriated significant funding to study vapor-based decontamination. This is a comprehensive research and development program for improving the chemistry of vapor-based decontamination systems and improving the delivery of these decontaminants. A primary area of interest within the congressional plus-ups is VHP technology for use in decontamination of aircraft and other combat vehicle interiors as well as other military

hardware. This effort will leverage the demonstrated capabilities of VHP for biological agent decontamination and extend this capability to chemical agent decon.

DOE

Vaporous hydrogen peroxide (VHP) appears to show great potential for the decontamination of biological agents in the interiors of buildings. VHP is highly sporicidal at very low concentrations at ambient temperature and pressure conditions and comparatively low relative humidity, with contact times of less that one hour. VHP appears to be significantly less corrosive than other free-radical producing sterilants, and has proved effective against a number of microorganisms, spores, and viruses. A significant advantage of VHP is that it breaks down into water vapor and oxygen. VHP generators are available commercially and have been used to sterilize clean rooms in the pharmaceutical industry.

This work focuses on building HVAC systems, both in the context of decontaminating the HVAC system itself, as well as using the HVAC system to introduce VHP into the building. Working with Steris Corporation, the project will:

- Evaluate the ability of VHP introduced into the room via the HVAC system to decontaminate aerosolized Bacillus spores
- Determine if spores can be transported into less accessible areas and if VHP introduced via the HVAC system can decontaminate these locations
- Conduct a survey of commercial building HVAC systems to categorize the variety of systems that may require decontamination
- Perform an engineering design review to determine how VHP generators could be interfaced with HVAC systems
- Demonstrate the use of VHP to decontaminate large office spaces or entire buildings

The Information Systems Roadmap

The summary level Information Systems Roadmap is shown in Figure 9 on the following two pages. The Roadmap covers relevant Acquisition/Transition activities and R&D programs from FY01 through FY12.

Figure 9. The Information Systems Roadmap

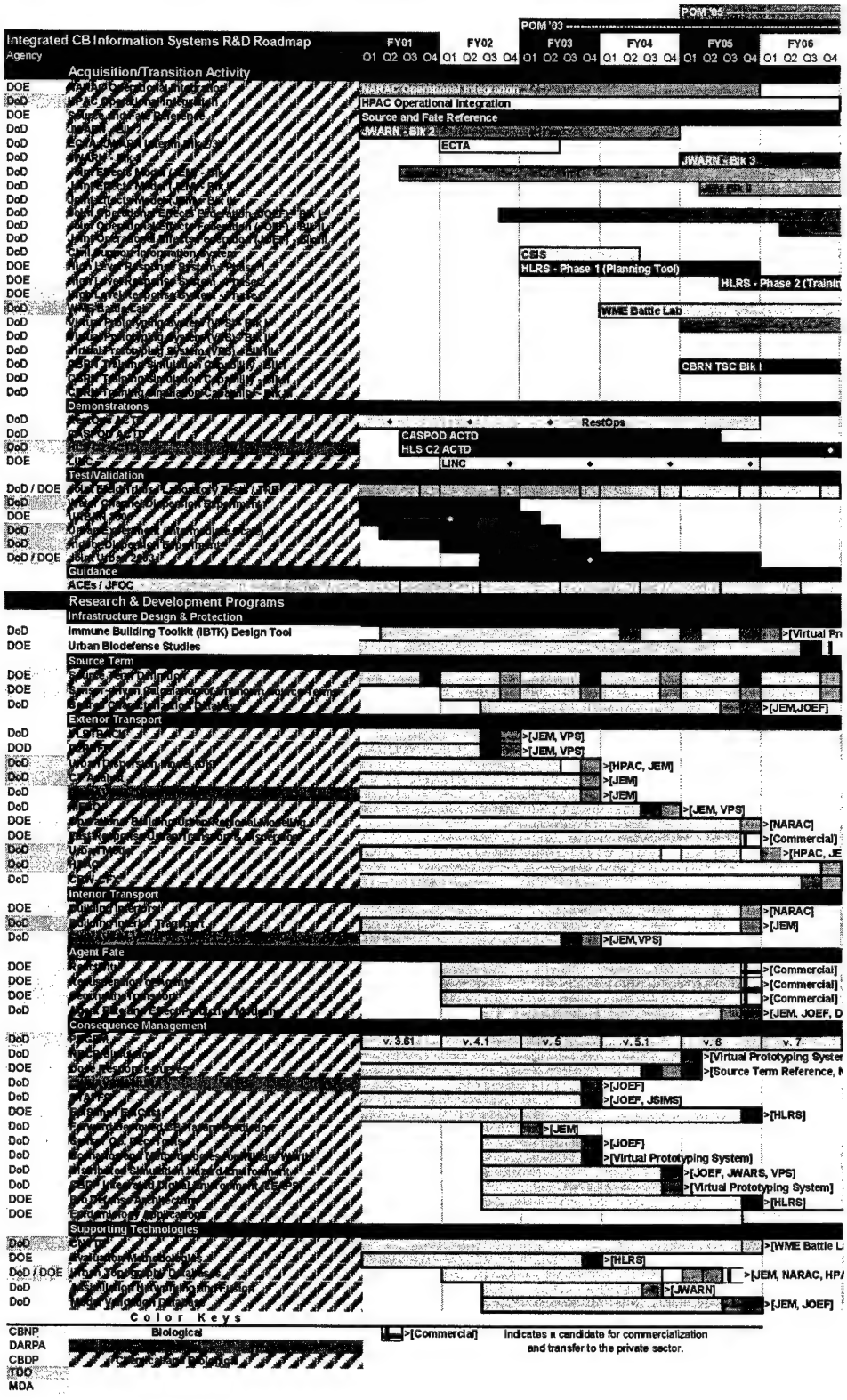
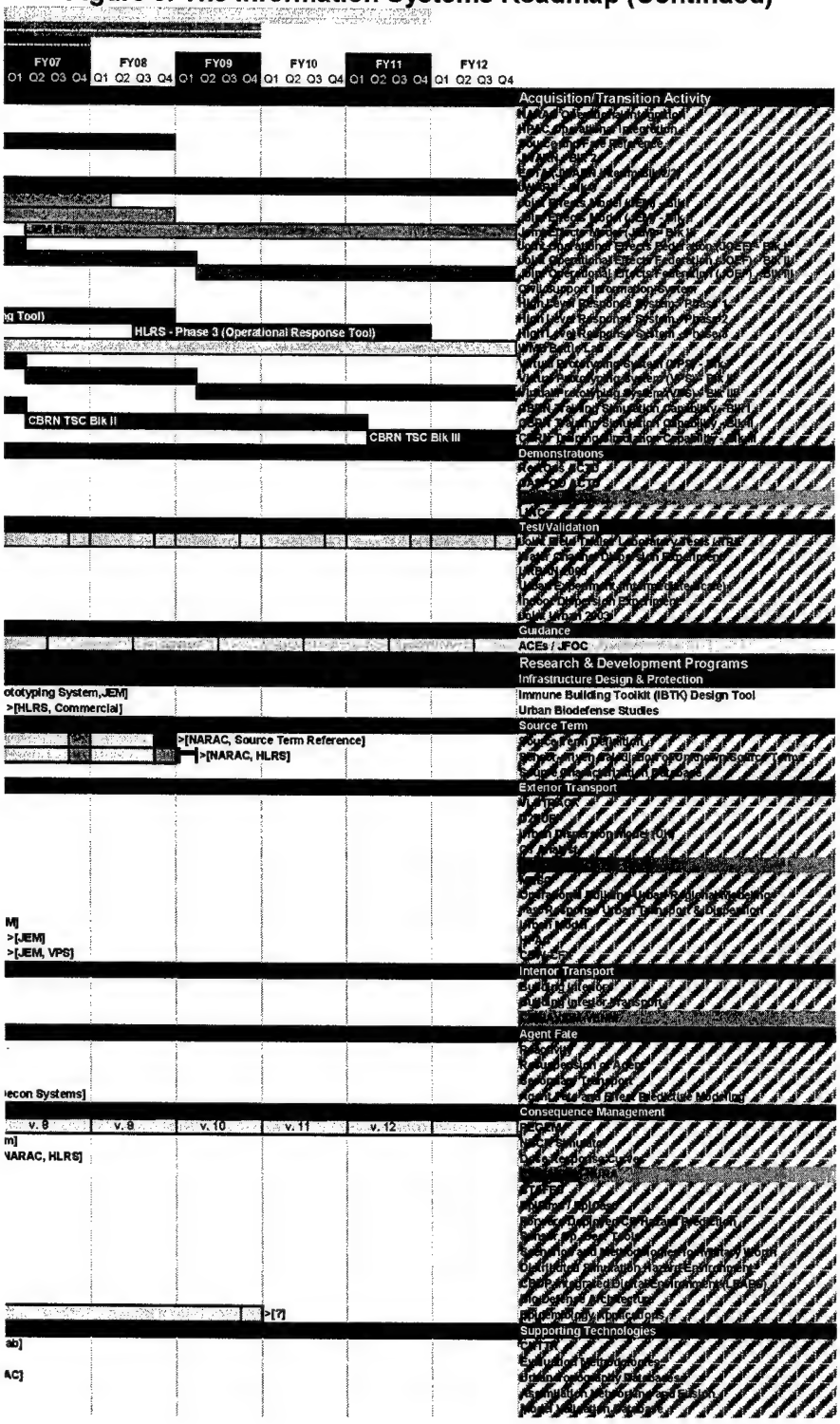


Figure 9. The Information Systems Roadmap (Continued)



Acquisition/Transition Activities Involving Information Systems Technologies

The DoD transition and acquisition activities, as well as the supporting R&D programs, contribute to requirements developed in two key pieces of guidance:

- The Joint Future Operational Capabilities (JFOCs) list developed by the Joint Services
- The prioritized CPRC Areas for Capability Enhancement (ACEs)

Specifically, activities and programs included in the Information Systems Roadmap support the development of warfighting capabilities for DoD ACE Priority 2: Detection, Identification, Characterization, Location, Prediction and Warning of CW and BW agents.

The DOE Transition activities are aimed at expanding the national capabilities for homeland security.

Information Systems: Current Programs and Projects

Figure 10. Information Systems Technology Groupings

Technology Group	Programs		Functional Areas
Infrastructure Design & Protection			
	• Immune Building Toolkit	**B**	Reducing the vulnerability of building to a BW attack
	• Urban Biodefense Studies	**B**	
Source Term			
	• Source Term Definition	**CB**	Deriving a model representation of a hazard source
	• Sensor-Driven Calculation UST	**CB**	
	• Source Characterization Database	**CB**	
Exterior Transport			
	• VLSTRACK	**CB**	Predicting the outdoor transport of hazardous material after an event
	• D2 PUFF	**CB**	
	• Urban Dispersion Model (UK)	**CB**	
	• CT Analyst	**CB**	
	• CWNAVSIM DAWN	**C**	
	• MESO	**CB**	
	• OBU-RM	**CB**	
	• Fast Response Urban	**CB**	
	• Urban Model	**CB**	
	• HPAC	**CB**	
	• CBW-CFX	**CB**	
Interior Transport			
	• Building Interiors	**CB**	Predicting the indoor transport of agents after an attack
	• Building Interior Transport	**CB**	
	• CWNAVSIM VENM	**C**	
Agent Fate			
	• Reactivity	**CB**	Predicting the temporal evolution and disposition of hazardous material
	• Resuspension of Agent	**CB**	
	• Secondary Transport	**CB**	
	• Agent Fate and Effect PM	**CB**	
Consequence Management			
	• PEGEM	**CB**	Modeling and optimizing the decision making structures and
	• NBCR Simulator	**CB**	
	• Dose Response Curves	**CB**	

Technology Group	Programs		Functional Areas
	• CWNAVSIM NURA	C	structures and communications required for responding to an event
	• STAFFS	CB	
	• EpiSims/EpiCast	CB	
	• FDCBHP	CB	
	• Sensor Op. Dec. Tool	CB	
	• Scenarios/Method. Military Worth	CB	
	• Distrib. Simulation Haz. Environ	CB	
	• CBDP Integ. Digital Environ (LEAPS)	CB	
	• Bio Defense Arch.	CB	
	• Epidemiology Applications	CB	
Supporting Technologies			
	• CNTTR	CB	Empirical data and techniques of general use to model development
	• Evaluation Methods	CB	
	• Urban Topography DB	CB	
	• Assimilation Network/Fusion	CB	
	• Model Validation DB	CB	

Findings

Status of the Information Systems Roadmap

The Information Systems Roadmap presented here should be viewed more as a "progress report" than as a finished product. When the initial roadmap schedule was prepared in 1999, the Focus Group recognized the complexity of this technology area, both in terms of the scope and variety of the research as well as the large number of organizations contributing to the collective body of knowledge on the subject. This recognition was the major factor in deferring work on the IS Roadmap until the roadmap process was better established and somewhat mature.

While the IS Roadmap is constructed on the same template as the CB Point Detection and the CB Decontamination Roadmaps, displaying the leveraging and interactions of the IS R&D programs has proved much more difficult than with the other roadmaps. The reason lies with the fundamentally different nature of this technology area; while there is hardware involved, most of the effort represented here is in the creation of intellectual property in the form of techniques and algorithms aimed at making practical use of the state-of-the-art in hazard evolution, in atmospheric and transport sciences, in the understanding of agent decay rates, and in the evolving decision making structures and the communication pathways required by those structures in order to function effectively.

The ultimate and primary consumer of the results from the research listed here is identified at the end of each program line; however, there are a number of testing and demonstration activities which have not yet been captured and integrated into this picture. Thus far, we have focused on capturing as many programs as time allowed while searching for the most effective organizational structure to present this body of work. The Focus Group settled on a functional decomposition of the research. Especially to a casual observer, this kind of functional structure answers the obvious first question, "What does it do?"

The categories are derived from the stages of a crisis event and from the tools that are developed to address circumstances arising at each stage. First, there is work to protect infrastructure, including effort to design safer new buildings and facilities as well as efforts to retrofit existing ones to provide a greater level of protection to occupants.

The next categories capture work to describe and predict the outcome of a hazardous event. They include efforts to understand and model the hazard source as it evolves, the transport of the hazardous material through the atmosphere both within buildings and outside in open spaces, the temporal decay rates of the hazardous material and its susceptibility to redistribution if disturbed, the decision making structures and decision sets available to everyone contributing to consequence management in the aftermath of an event, and lastly, the methodologies and resources created and supported for the general use of all who work in the aforementioned areas.

Redundancy Analysis

As for duplication of efforts, this process is not yet advanced enough to offer an assessment. However, one event does appear to have provided a major impetus to coordination and leveraging efforts at least within the Department of Defense—the appointment of a single office as the Milestone Decision Authority for Modeling and Simulation.

The Larger Community's Assessments

As constructed, the Roadmap shows little R&D past FY06. The listed R&D activities principally focus on using existing capabilities and do not show how the limitations of present knowledge are overcome to provide high resolution, locally dependent, highly reliable capabilities for support to military mission execution and mission planning.

The scientific complexities and challenges facing research and development in the Atmospheric Sciences, especially in the atmospheric boundary layer (ABL), have been examined by several entities. Within these studies, there is an awareness of the challenges for atmospheric transport and diffusion pre- and post- September 11, 2001. The findings generally overlap one another.

In "The Atmospheric Sciences Entering the Twenty-first Century," The Board on Atmospheric Sciences and Climate of The National Research Council made five recommendations for Boundary Layer Research -- Structure of cloudy boundary layers; Turbulence and entrainment; Effects of inhomogeneity and baroclinity on the boundary layer; Measurements of the exchange of water, heat, and trace atmospheric constituents at the earth's surface; and Interactions of the planetary boundary layer, surface characteristics and clouds -- and two recommendations for Improvement of Capabilities -- Develop new measurement techniques and Develop new analysis techniques. All of these topics are applicable to Information Systems.

The 1999 "JASON Civilian Biodefense Study" briefly addressed the ABL. They find that the current parameterizations of mean profiles belie the fact that the ABL is unpredictable, and the present state-of-the-art in theory and modeling is unsatisfactory and would benefit by a host of well-characterized daytime and nighttime laboratory and field experiments.

The recent Joint Action Group for Selection and Evaluation for Atmospheric Transport and Diffusion Models of the Office of the Federal Coordinator examined the current state of the art and science and identified gaps in the knowledge and practice. Seven primary recommendations were made, with multiple subtopics. Furthermore, the following research needs were identified and discussed: Source characterization; Chemical mixtures; Collaboration and coordination; Limits of predictability; Measurement strategies; Characterization of the urban canopy; Urban dispersion; The planetary boundary layer (PBL); PBL modeling errors; Coastal influences; Concentration variability; Deposition rates; Re-suspension; Cross-media interactions; Chronic health effects; Complex terrain; Indoor-outdoor interactions; Nocturnal boundary layer; and Land surface models.

The 2001 Basic Research Plan for the Army Atmospheric Sciences identifies two primary thrust areas for Basic Research, related to atmospheric transport and diffusion. One thrust is Characterization of the Atmosphere at High Resolution, which includes diurnal boundary layer evolution, dispersion of CB agents and obscurants, 4-D(imensional) measurements of boundary layer variables, and highly heterogeneous environments. Another thrust area is the Management and Application of Atmospheric Information. This thrust includes topics of uncertainties of models, nowcasting and data management, and development of innovative high performance computational methods. Even across thrusts, no one subtopic stands alone. This is a coupled problem—understanding the fundamental processes across multiple scales through measurements (that may not currently exist), converting that knowledge to robust parameterizations, utilization of multiple platforms and data resources to support the parameterizations, and integration into real-time, useable products, like tactical decision aids and model predictions, with a measure of confidence attached. The problem, being nonlinear, should be addressed holistically on multiple fronts, rather than sequentially by "product" or system, once again underscoring the importance of coordinated interagency planning of research.

In the coupled meteorological-dispersion system, the primary challenge lies in the representation of the atmospheric conditions consistent with the time and space scales affecting the local transport and diffusion of induced material (gas or aerosol). The challenge is extremely difficult in that the ABL is the most varied and changeable part of the atmosphere. Unfortunately, the higher the resolution required, the less is known of the spatial and temporal behavior of the atmosphere. Atmospheric mesoscale models are poorly coupled to the dynamic, diurnal behavior of the boundary layer.

It is unlikely, due to the complexity of these topics, that a comprehensive, unified model of atmospheric behavior on the small unit operations scale will be achieved within the upcoming 20 years. The basic research effort will persist and prevail by continuing to identify programs to address these needs and sponsoring promising, innovative ideas and concepts as they develop over time. Progress will likely be evolutionary rather than revolutionary, but progress will occur with persistence.

Conclusion

The various Focus Group members believe that their efforts to foster CBD RDA integration between DoD and DOE have yielded progress over the past year.

- First, the groups updated the CB Point and Decontamination Roadmaps.
- Second, progress in interagency coordination has expanded this year with the addition of the EPA Decon effort.
- Third, the groups have expanded their membership to include TSWG, NIJ, DTRA, EPA, MDA and some representatives of the IC.
- Finally, the significant gap in FY05 and beyond transition opportunities remains an issue.

APPENDIX A

Acquisition/Transition Activities Involving CB Detection Technologies

The transition and acquisition activities to which CB point detection research and development programs and DoD and DOE make significant contributions are introduced below.

Engineering and Manufacturing Development (EMD) Programs

JCAD (DoD): DoD CBDP

The focus of the Joint Chemical Agent Detector (JCAD) RDTE effort is to develop a point chemical vapor detection system that will satisfy a range of military requirements and platforms. Service requirements include: Individual Soldier Detection (ISD), Special Operation Force Chemical Agent Detector (SOFCAS), Individual Vapor Detector (IVD), Aircraft Interior Detector (AIDET), Shipboard Chemical Agent Monitor Portable (SCAMP), CW Interior Compartment System (CWICS) and Improved Chemical Detection System (ICDS). The system is currently under development and is scheduled for procurement and fielding. The current program timeline shows activity into FY02.

JBPDS EMD: DoD CBDP

The Joint Biological Point Detection System (JBPDS) program will provide a common integrated biological point detection suite for use by all services. It will be used to protect air bases, ports, ships and forces. It will automatically detect and identify 10 biological warfare (BW) agents. A major challenge being addressed for Operational Testing is whole-system, live, pathogenic agent testing versus component-level testing. The need for testing in various locations, real-time data acquisition, and reduced test costs requires a standoff-type referee system. To improve reliability, a hardened calibration and confidence device is planned. On-going efforts are centered on decreasing system size, weight and power and increasing system sensitivity. A major component for improvement will be the advanced BAWS to increase sensitivity and to reduce operation cost. The program timeline is FY98 through FY06.

JMCBD EMD: DoD CBDP

The Joint Modular Chemical Biological Detector program goal is to generate a detection device that can be used alone or in networks and can identify both chemical and biological agents. This system begins EMD in FY08. The roadmap shows possible candidate R&D systems for transition into JMCBD to include Bio Time of Flight Mass Spectrometer, the Advanced Multifunction Biochip, μChemLab, Pyrolysis-GC/Ion Mobility Spectrometry, Optical Particle Classifier, Aerosol Samplers, and/or tactical level systems. The program timeline is FY08–11.

Portal Shield: DoD CBDP

Portal Shield is a fielded, point detection system currently in production and utilized by the Combatant Commanders (COCOMs) of both Pacific Command (PACOM) and Central Command (CENTCOM) to provide biological detection capabilities for fixed sites (ports of embarkation/debarkation) against small-scale releases. Portal Sheild was initiated as an Advanced Concept Technology Demonstration (ACTD) to evaluate the military utility of a biological detection network capability, to develop operational procedures for that capability, and to provide a residual capability to detect, warn, de-warn and presumptively identify a BW attack on a high priority fixed site. The Portal Shield system is a network of sensors linked to a central Command Post (CP) computer that monitors the operational status of the sensors, controls the networked sensors, evaluates network data to determine if a BW attack has occurred, and alerts the operator

to a BW event. There are no further developments on this program. Efforts have merged into the JBPDS program.

CB Agent Water Monitor DTO: DoD CBDP

The Agent Water Monitor project is investigating technologies to develop a capability to detect, identify and quantify CB agents in source, treated and distributed potable water supplies. A market survey identifying and ranking some 150 technologies was conducted, with five technologies being selected for focused investigation. These technologies are Attenuated Total Reflectance–FTIR, Molecular Imprinted Polymer Sensor, Dendrimer-based Antibody Assays, Pyrolysis-GC-ion mobility spectrometry, and surface enhanced Raman spectroscopy. Data are being developed to support downselect of technologies to be incorporated in breadboard build in FY03 with demonstration in FY04. Target transition is to Joint Chemical Biological Agent Water Monitor EMD in FY05. The program timeline is FY01–04.

BioBriefcase: DOE CBNP

BioBriefcase is a collaborative project between Lawrence Livermore National Laboratory and Sandia National Laboratory. The end-product is a briefcase-sized instrument capable of detecting the full spectrum of biowarfare agents (bacteria, viruses, and toxins). This new system is a revolutionary departure from current technologies under development, yet leverages the successes of the operationally proven Autonomous Pathogen Detection System (APDS) and μChemLab Systems. The BioBriefcase will feature multiplex capability, dramatically reduced reagent consumption, decreased cost, and decreased size, while maintaining or improving sensitivity and response time compared to currently available technologies. These achievements are possible through: a) the exploitation of electrophoretic tags (eTags) which enable multiplex separation and detection of all classes of bioagents using capillary electrophoresis, b) chip-based sample processing modules, and c) micro fluidics for sample handling.

Demonstrations

Biological Aerosol Sentry and Information System (BASIS): DOE CBNP

The BASIS program is focused on developing early DI&W systems for limited duration bio-agent aerosol monitoring during special events such as major sporting events and political conventions. BASIS has successfully demonstrated architectures for special events and wide area monitoring, including successful deployments at the 2002 Winter Olympics in Salt Lake City and in events after September 11, 2001. BASIS is being transitioned to DOE emergency operations, and the fundamental architectural elements are also being incorporated into the DTRA National BioDetection Initiative Testbed. The program timeline is FY00–02. The roadmap shows possible candidate R&D systems for transition into BASIS to include CBNP Nucleic Acid Based Assays.

Restoration of Operations ACTD (RestOps): DoD CBDP

The Restorations of Operations Advanced Concept Technology Demonstration (ACTD) will demonstrate those actions taken before, during and after an attack to *protect against* and *immediately react* to the consequences of a CB attack. These actions aim to restore operating tempo (OPTEMPO) in the execution of the mission and in the movement of individuals and materiel to support combat operations at a fixed site. One goal of this ACTD is to generate improved chemical and biological warfare detection technologies in an effort to reduce vulnerabilities at a fixed site. Candidate technologies will be tested during Joint Chemical Field Trial testing at DPG and subsequently down-selected for further testing during the ACTD. The ACTD is currently scheduled for the Final Demonstration to occur in FY03, which will be followed by two years of residual support at Osan Airbase.

Program for Response Options and Technology Enhancements for Chemical/Biological Terrorism (PROTECT): DOE CBNP

The PROTECT program is focused on developing and deploying early CB agent detection, identification and warning (DI&W) systems for vulnerable, heavily populated civilian facilities such as subway systems and airports. The subway component has been accelerated and will be completed in FY02. Emphasis will then be increased in airport protection. The program timeline is FY00–FY04. The roadmap shows possible candidate R&D systems for transition into PROTECT to include APDS, Gene Chip Biosensor, Advanced Multi-Functional Biochip, Argonne MAGIChip, μChemLab, PY–GC/IMS and Optical Particle Classifier.

Chemical Combat Assessment System (CCAS) ACTD: DoD CBDP

The CP2 ACTD Chemical Combat Assessment System (CCAS) consists of a rapid, field-modification kit for the Predator RQ–1B Medium Altitude Endurance (MAE) UAV to perform chemical combat assessment missions to detect, identify, track, characterize and collect chemical effluent following counterforce strike missions. Predator modifications for the CCAS kit require removal of the Tactical Endurance Synthetic Aperture Radar (TESAR) payload, integration of the Predator Infrared Airborne Narrowband Hyperspectral Combat Assessor (PIRANHA), and installation of compatible Predator wings along with a dispenser sub-system for two Flight Inserted Detection Expendables for Reconnaissance (FINDER) mini-UAVs. PIRANHA is a Fourier Transform Infrared (FTIR) remote sensor. Each FINDER contains a Spectrometric Point Ionizing Detector Expendable/Recoverable (SPIDER) point sensor (consisting of two Ion Mobility Spectrometer (IMS) point sensors for redundancy) and an integrated sample collector. The FINDER mini-UAVs are carried into the target area attached to the Predator outboard wing hard points. Technologies considered in this ACTD consist of already fielded government technologies or COTS products. The ACTD is currently scheduled for Operational Demonstrations in Jan 03 and Mar 03. The ACTD ends in Q2FY03 and is followed by two years of residual support (four kits).

Bioforensics: DOE CBNP

The purpose of the Bioforensics program is to transition DOE bioforensic capabilities from the laboratory into the hands of intended users: law enforcement, the judiciary, public health and national security. These capabilities consist of a spectrum of DNA-based techniques that will help the user address a number of bioforensic challenges such as recognizing and documenting a bioterrorist attack and distinguishing it from natural disease outbreak. The program timeline is FY01–05. The roadmap shows possible candidate R&D systems for transition into Bioforensics to include CBNP Nucleic Acid Based Assays.

Contamination Avoidance at Seaports of Debarkation (CASPOD): DoD CBDP

Seaports of debarkation (SPODs) are recognized as critical assets for power projection and force deployment operations, making them attractive targets for exploitation. Unified Combatant Commanders have responsibility to defend SPODs against terrorist or other adversary CB, Toxic Industrial Chemical (TIC), or Toxic Industrial Material (TIM) attacks/releases. The CASPOD ACTD will leverage work done in other projects (Seaport Protection Analysis (SPPA) project and the RestOps ACTD) to identify and provide technologies, capabilities and procedures that can be utilized prior to, during, or after an attack/release to mitigate effects on time phased force deployment data (TPFDD) flow. Operational concepts and TTPs to initiate and sustain CB and TIC/TIM defense operations at SPODs will be demonstrated. The force structure necessary to implement procedural and equipment requirements will be identified and refined. A resident/pre-positioned or rapidly transportable CB and TIC/TIM defense equipment and material packages needed for employment at SPODs will be developed and demonstrated. Strategic operational improvements/shortfalls for CASPOD contingencies will be identified. In addition, a forum,

process and structure for addressing and modifying U.S., coalition and host nation policy issues will be provided. The ACTD demonstration phase is currently scheduled from FY02–04, with transition occurring in FY05–06.

Domestic Chemical Assessment System (DCAS) ACTD: DoD CBDP

DCAS will detect, identify, track and characterize domestic releases of toxic chemicals. It is based on the current CCAS system architecture and will leverage prototyping and integration accomplishments from the CCAS. DCAS will consist of the following: one PIRANHA (Predator Infrared Airborne Narrowband Hyperspectral Combat Assessor) remote sensor, purchase of spares and ground support equipment and personnel; one Twin Otter aircraft with aircrew to host PIRANHA sensor; two SPIDERs (Spectrometric Point Ionizing Detector Expendable and Recoverable) point sensors, purchase of Ground Station, purchase of spares and personnel; and two FINDERs (Flight Inserted Detection Expendable for Reconnaissance) mini-UAVs and personnel. In the domestic role, DCAS will provide deterrence, indication and warning of release of chemical vapors in an urban environment. DCAS will be deployed to cover specific events or designated, high priority geographic areas with the capability of 24-hour sustained operations using contactor personnel. Technologies considered in this ACTD consist of already fielded government technologies or COTS products. Projected end-users include Homeland Security/Defense and National and Local Law Enforcement agencies. The ACTD is scheduled to initiate late in Jul 02 with system deployment by Jun 03.

Biological Combat Assessment System (BCAS) ACTD: DoD CBDP

BCAS will provide capability to the warfighter to plan, execute and assess counterforce strikes against fixed Biological Warfare (BW) facilities. The system will detect, identify, track, characterize and collect BW aerosol agents released during counterforce strikes. The system will be capable of assessing the post-strike plume for BW agents of interest (bacteria, viruses and toxins including anthrax, plague and ricin) to address existing COCOM requirements and AF MNS CAF 328–92. A phased approach will be employed to prototype and demonstrate incremental technologies. Each phase will deliver technologies with potential stand-alone capabilities to reduce program risk. Phase 1 will prototype, integrate and demonstrate the capability to collect BW agents from a post-strike plume. Phase 2 will prototype, integrate and demonstrate the capability to detect and identify BW agents using a point/contact detector/identifier. Phase 3 will develop, prototype, integrate and demonstrate the capability to detect BW agents using a stand-off sensor. Each phase will build upon the success of the previous phase with an integrated end product incorporating all technologies. The system will employ orthogonal technologies for detection and identification to provide an acceptably low false alarm rate. The current leading technologies for point detectors/identifiers are antibody-based and deoxyribonucleic acid (DNA) based identification systems. The state of the art for stand-off detection is limited to detecting the presence of biological constituents in the plume; stand-off identification of specific agents cannot be accomplished with current technologies. Technologies considered in this ACTD consist of already fielded government technologies or COTS products. The ACTD is anticipated to be a four-year program, initiating in FY03, ending in FY06 and having two years of residual support through the end of FY08. Technologies considered in this ACTD consist of already fielded government technologies or COTS products.

Test/Validation

Critical Reagents Program (CRP): DoD CBDP

The CRP was created by the Joint Program Office for Biological Defense (JPO–BD) in accordance with FDA requirements to ensure security and availability of standardized high quality antibodies, antigens and gene probes and primers for biological warfare detection systems. In addition, the CRP is responsible for the production of the HHA's, which are the identification

components in many existing biological detection systems as well as DoD Biological Sampling kits. CRP will end in FY03 and be transitioned to support medical systems.

Joint Field Trials (JFT): DoD CBDP

The purpose of the JPO–BD JFT program is to evaluate new and existing technologies for incorporation into biological defense programs. JPO–BD sponsors a JFT test once a year in which developers provide test items that are evaluated by analysis teams. This roadmap includes the testing of several technologies. Successful technologies are subsequently matured for integration into detection systems. Program timeline initiates in FY98 and has no termination. The majority of Sensor/System R&D program items take place in JFT testing at some time (see roadmap).

Within the JFT are the Joint Chemical Field Trials (JCFT). This testing is being sponsored by the Defense Threat Reduction Agency in an effort to facilitate the identification of technologies that will be utilized in the RestOps and CASPOD ACTDs. JCFT testing was held at WDTC, Dugway Proving Grounds, from 2QFY00 through 2QFY01. Once technologies have been technically evaluated in JCFT, they will subsequently be analyzed in operational testing for military utility. Successful technologies will eligible for acquisition.

Guidance

Areas for Capability Enhancement (ACEs): DoD CBDP

The ACEs are established by the Counterproliferation Program Review Committee (CPRC). The ACEs were established to characterize those areas where progress is needed to enhance both the warfighting capabilities of the Combatant Commanders (COCOMS) and the overall ability to satisfy the demands of U.S. counterproliferation policy. A detailed discussion of each ACE along with agencies programs to support each ACE can be found in the 2003 CPRC Report on Activities and Programs for Countering Proliferation and NBC Terrorism. The ACEs provide broad guidelines for R&D/acquisition investment and prioritizes areas where additional capabilities are required to meet the challenges posed by WMD proliferation threats. There is one ACE that addresses detection, identification, characterization and warning of CBW agents (ACE 2: Detection, Identification, Characterization, Location, Prediction and Warning of CW and BW agents); these point detection programs support that ACE. The ACEs timeline is unlimited.

Joint Future Operational Capabilities (JFOC): DoD CBDP

JFOC was established by the Joint Service Integration Group in an effort to identify and prioritize Joint User far-term future operational capabilities as expressed in the emerging Joint NBC Defense Concept. The overall intent is to provide enhanced user guidance to the Joint NBC Defense Science and Technology (S&T) community to assist in the NBC S&T program formulation and execution process. Prioritized Joint Future Operational Capabilities include:

- Contamination Avoidance[5]
- NBC Battle Management
- Individual Protection
- Restoration Capability
- Collective Protection

A detailed description of JFOC can be found in the NBC Defense Annual Report. The JFOC timeline is unlimited.

[5] Point and Standoff Detection are included within the JFOC definition of Contamination Avoidance.

CB Detection and Identification: Research and Development

Sensor/System R&D programs include CB Point detection and Identification, Reagents/Assay development, and Supporting Technologies. Biological Point Detection and Identification Programs are further subdivided into major activity areas: Genetic Detection, Detector on a Chip, Mass Spectrometry, Handheld Systems, and other programs that have not yet been categorized.

Genetic Detection

Handheld Advanced Nucleic Acid Analyzer (HANAA): DOE/CBNP

The objective of this project is to develop an advanced technology for the detection of biological warfare agents. The HANAA analyzes biological samples for the presence of specific DNA sequences. The HANAA operation is based on the detection of Taqman flurophors from DNA products generated during the polymerase chain reaction (PCR). Taqman PCR uses special fluorescent probes attached to the replicated DNA to provide real-time detection. The HANAA provides a man-portable, handheld, field-worthy PCR bio-detection instrument. It is ideally suited for emergency response where biological pathogens are suspected and for field monitoring where portability and fast answers are critical. It can also be used in intelligence, combat or reconnaissance missions. Current commercialization efforts involve building a small number of evaluation instruments by the end of this year. The roadmap shows that instruments will be for sale in June 2002.

Automated Genetic Identifier: DoD CBDP

This DTO supports QDR transformation goals to protect bases of operation. It will develop and demonstrate technology to reduce the logistics burden associated with biological identification through an advanced, automated, Biological Identification System based upon genetic detection and identification technology. The primary objective to reduce the logistics burden is only partially handled by an automated sample preparation system. Consumables continue to be the major logistics impact for biological warfare agent detection and identification systems. The extended work will focus on the reduction of the total number of required assays through multiplexing/multi-agent analysis within a single sample.

Autonomous Pathogen Detection System (APDS): DOE CBNP

The LLNL APDS is a stand-alone instrument designed to provide automated, continuous monitoring of aerosols for detection and identification of potential biological agents. Major components include an aerosol collector, sample preparation module, flow cytometer, and Polymerase Chain Reaction (PCR) thermocycler. The system is presently being designed to utilize a combination of both multiplex immuno based flow cytometer and genetic recognition (via PCR) assays. The current goal is to complete a fieldable prototype with immunoassays only in FY02, adding the PCR component in FY04. The roadmap shows transition opportunities for APDS to include the PROTECT sensor testbed in FY04.

PCR Detection of Threat Bacteria: DOE CBNP

This project uses the polymerase chain reaction (PCR) assay which uses DNA primers to locate specific DNA sequences of interest and polymerase enzyme to repeatedly copy ("amplify") the sequence. Work will include the implementation of "eTag" assay developed by ACLARA BioSciences to perform solution-phase multiplexing. Work will also focus on miniature flow-through lyses and PCR modules. The reaction products are analyzed by capillary electrophoresis (CE). This assay is applicable directly to DNA from bacteria and viruses and with modification to RNA from these pathogens.

Field Sampler Extractor: TSWG

The Field Sample Extractor (FSE) project is developing a simple, easy to operate, inexpensive, and portable generic front-end device to process biological agent samples delivering analysis-ready DNA to a range of identification systems. The FSE will be used for non-intrusive environmental field sampling of a wide variety of biological materials in diverse and complex sample matrices resulting in a processed DNA sample compatible with the full range of polymerase chain reaction (PCR) technologies. Execution of this project will involve work in the following areas: development and optimization of a DNA extraction matrix, design and testing of a sample disruption unit, integrated device engineering, development of sample processing protocols, and testing of the FSE unit. The FSE will be applicable to missions such as military reconnaissance, intelligence collection, preventative inspections, post-event forensics, first response, and arms-control verification inspection. The project begins in Q3FY03 with prototype evaluation Q4FY04

Detector on a Chip

MAGIChip: DoD DARPA

The Argonne National Laboratory's MAGIChip is a microchip sensor being developed for the identification of pathogenic organisms. MAGIChip biomolecular reactions take place in a polyacrylamide gel matrix that provides a controllable, 3–D liquid phase environment in which multiple analysis may be performed. MAGIChip capabilities include identification of both RNA and DNA targets, toxin proteins, strain mutations, PCR amplification and distinguishing between alive and dead organisms. The chips can be regenerated and used several times. This technology is easily amenable to automation. The roadmap shows transition opportunities for the MAGIChip to include the PROTECT sensor testbed in FY04.

Advanced Multi-Function Biochip (AMB): DOE CBNP

The AMB is a fully integrated fluorescence based microelectronic device developed by ORNL in collaboration with Becton Dickinson and Honeywell. AMB capabilities include bioassay multiplexing generated by engineering different types (DNA, antibody, enzyme) of bio-receptors on the same chip. Genetic and immunologic assay systems include Strand Displacement Amplification (SDA) and Enzyme-Linked Immunosorbent Assay (ELISA) methodologies, respectively. Aerosol collection and sample processing will be provided by mesopump and ultrasound based technologies. The roadmap shows transition opportunities for AMB to include the PROTECT sensor testbed and JCBAWM in FY04.

Gene Chip Biosensor: DoD CBDP

The Gene Chip Biosensor, under development at ECBC, objectives are to first individually develop and then to demonstrate proof-of-principle integration of two DNA technologies that will offer an enhanced capability over current methods to detect and identify bacterial and viral bioagents, at the strain level, in samples of unknown composition. The two technologies are "universal" PCR amplification and DNA Microarray ("gene chip") analysis. The PCR will use a "universal" random primer set and fluorophore-nucleotide conjugates to amplify and label all DNA present in a sample. Species and strain-level identification of the amplified genetic material will be carried out through the use of a DNA microarray. This work will also begin to integrate the two technologies for use in a complete DNA detector. The roadmap shows transition opportunities for the Gene Chip Biosensor to include the PROTECT sensor testbed in FY04.

Activity Based Detection and Diagnostics: DoD DARPA

This program is being developed to demonstrate that living cells and tissues can be engineered to detect biological and chemical threats. These cell/tissue based biosensor systems

could potentially provide dramatic new capabilities for sensing the activity of existing, emerging and engineered biological and chemical warfare threats or hazards. The approach is to extract cell/tissue agent response signatures from living systems and ultimately put these signatures on a chip platform.

Mass Spectrometry

Bio Sample Prep System DTO–ESI/MS (BSPS): DoD CBDP

The ECBC BSPS is an automated sample processing system that has the capability to lyse and process spores, bacteria and virus samples. Lysis methodology is still being optimized; however, down-select processes have shown the Cepheid bead-based ultra-sonication to be the current method of choice for the genetic platform. The processed sample is characterized by a Taqman-based PCR. Nucleic acid detection reagents against eight bacterial and viral agents are in development. The roadmap shows transition opportunities for BSPS–PCR to include JBPDS in FY02. This program has been renamed as Automatic Genetic Identifier and will continue through FY05.

Science and Engineering Services Incorporated (SESI) Infrared Mass Spectrometer: DoD DARPA

The SESI mass spectrometer was uniquely designed to identify biological agents. The system utilizes an infrared and ultraviolet laser desorption ionization process for sample ionization. This process generates more signature masses than conventional ionization methods, which provides a higher level of certainty in bioagent identification. This is an important capability, especially when considering spore forming bacteria. This project was funded only through the end of FY02.

Bio Time of Flight Mass Spectrometer: DoD DARPA

The Bio–TOF MS is being developed for the detection of aerosolized bio-agents, including bacteria, virus and toxin threats. It utilizes a unique sample ionization process called Matrix Assisted Laser Desorption Ionization. The mass spectrometer is a miniature time-of-flight instrument (TOF). The Bio–TOF is designed for completely automated aerosol collection, processing and identification of threats (See Appendix B for more details). Key accomplishments to date include completion of an extensive signature collection of both threats and interferents on laboratory instruments and data collection and performance evaluation on anthrax simulant Bg. The roadmap shows transition opportunities for this technology to include JBPDS in FY02 and JSCBD in FY08.

Advanced Ion Trap Mass Spectrometer: DOE CBNP

ORNL is developing a mass spectrometer system that will provide for simultaneous detection and identification of bio-agent protein targets. Proteins were the target of choice due to their ubiquitous nature in each biological threat category: bacteria, virus and toxin. The technique utilizes an electrospray/Ion-Ion chemistry process that facilitates mass spectrometric analysis of proteins. This program was not funded after FY01 due to competing priorities for resources.

Real-Time Bioaerosol Mass Spectrometry: TSWG CBRNP

The Real-Time Bioaerosol Mass Spectrometer (BAMS) measures mass spectra of individual biological aerosol particles on the fly in less than one second. No sample preparation or reagents are required. The aerosol particles are drawn directly into the instrument from the atmosphere without a separate sample concentration stage. The positive and negative ion spectra are produced continuously by laser ablation of particles in the threat size range at a rate of about 10 per second. By analyzing individual particles, the background noise in the mass spectra is dramatically reduced. The mass spectra from Bacillus cereus, Bacillus subtilis var niger and

Bacillus thuringiensis spores are unique, reproducible and readily distinguishable from each other and from spectra of common vegetative bacteria, fungal spores and common food/industrial powders. The analysis of the spectra is automated, and an algorithm rapidly identifies the threat agents providing alarm and quantifying the results. Capability for the real-time identification of Mycobacteria (using a common non-pathogenic tuberculosis simulant) has also been demonstrated. The project builds on an exploratory DOE research effort with TSWG funding support for applied development beginning in Q3FY02. Continued expansion of the identification library and engineering to reduce the size of the instrument will continue through Q4FY04.

Handheld Systems

Chemical Agent Detection Badges: DOE (LANL)

Chemical Agent Detection Badges (CADB) are being developed to provide detection of air and waterborne chemical warfare agents. A miniature, lightweight (<8 oz.), self-contained, battery powered sensor for the detection and identification of chemical agents is the goal of this effort. The prototype CW sensing devices will consist of replaceable electrochemical sensors together with batteries, pump or fan, and measurement electronics. Potential user applications include: a 'film badge' or 'pager' for warning of the presence of chemical agents; a remotely monitored, unattended package with integrated telemetry; a base technology for electrochemical decontamination; and a patch for probing breakthrough of agents across a protective clothing barrier. The system may also be potentially adaptable to some biological agents. A review of the Roadmap shows two key milestones. Q4FY01 testing will demonstrate response of a stand-alone prototype device to 3 chemical warfare agents and 2 domestic chemical targets at ppm levels. Q4FY02 testing will demonstrate response of a stand-alone prototype to airborne chemicals at sub-ppm levels. Intended users include first responders as well as fixed and mobile monitoring networks.

μChemLab: DOE CBNP

The objective of this project is to develop a fully self-contained, user friendly, hand-held unit for the detection and analysis of the full range of chemical and biological threats. Intended users include first responders as well as fixed and mobile monitoring networks. The technical approach utilizes micro-machined chips that contain parallel and serial micro-separation columns/channels. The **μChemLab/CB** currently exists as two separate systems, one for chemical agent detection and the other for biological agent detection. The biological system utilizes micro-scale, liquid phase chromatography and capillary electrophoresis together with laser-induced fluorescence (LIF) detection to provide sensitive analyses at low nanomolar concentration levels. The chemical system utilizes cascading of sample preconcentration, gas chromatography separation and surface acoustic wave (SAW) detection to provide high sensitivity and chemically selective detection. Performance goals are at ppb sensitivity for nerve agents and 10 ppb for blister agents with a detection time of 1 minute. Late FY00 live agent testing of the CW research prototype at ECBC demonstrated excellent performance against a range of nerve and blister agents in the presence or absence of realistic interferents. Other roadmap and milestone events include: CW prototype testing in PROTECT DDAP in FY01; demonstration of CW/TIC research prototype in FY03; and completion of CW/TIC engineering prototype for use in field trials by FY04. Transition opportunities for **μChemLab/CW** and **μChemLab/BW** individual systems include the PROTECT sensor test bed in FY02 and FY04. In addition, both chemical and biological detection capabilities are scheduled to be integrated into the same system by FY04. Transition opportunities for the integrated CB system include JCBAWM and JSCBD in FY08.

Personal Alarm Monitor: TSWG/CBRNC

The Personal Alarm Monitor effort develops and tests a prototype system for warning of the individual of exposure to selected chemical agents in sufficient time to escape or don respiratory protection. The initial focus for phase I is nerve agents. An initial chemical, visual alert badge prototype has been completed and the design is currently being modified to incorporate an electronic alert. Intended users for these products include civilian law enforcement and other emergency responders. The prototype sensor with electronic alarm capabilities was recently tested against nerve agents at ECBC with satisfactory results for sensitivity and response time. The program was initiated in FY 00, and final chemical agent badge prototypes are in production for delivery Q3FY03. The Phase II biological agent collection badge portion of this effort has been terminated.

Up-Converting Phosphor Hand Held Assay: DoD CBDP

The SRI UCPHHA utilizes the same UCP technology as the UCPFCM. The primary objective of this project is to evaluate UCP technology in the U.S. Government standard hand held assay (HHA) format using Government Furnished Equipment (GFE) antibodies. A secondary objective is to develop a hardened handheld biosensor that incorporates UCP based HHA strips for field operation. Research is already underway in modifying the standard HHA with UCP technology. A Multi-target Lateral Flow Wick Assay has been developed that has demonstrated multiple target identification in the same assay.

SMALLCAD: TSWG/CBRNC

The SMALLCAD chemical agent detector project integrates two mature chemical detection technologies, ion mobility spectroscopy (IMS) and surface acoustic wave (SAW). The system utilizes a two channel auctioning algorithm to dramatically reduce the false positive rate. Fusing the outputs from two orthogonal detection systems has already been accomplished and demonstrated dramatic reduction in the false alarm rate during extensive testing against a library of interfering materials frequently encountered in an urban environment. To meet operational requirements, SMALLCAD will use miniaturized detectors. The reduction in detector size has already been accomplished by the subcontractors and tested. Two technical issues currently being addressed include refinement and testing of the sensor fusion algorithm to minimize false negative response and power management. The Special Operations Forces is the intended user for the SMALLCAD. The program was initiated in Q4FY00 and is scheduled for prototype completion in April 2002. The SMALLCAD prototype has been tested at TNO Netherlands with satisfactory performance against a selection of nerve agents. Field prototypes have been delivered to the user, and the system is being evaluated in alternative deployment modes. Production items will be available in fall FY03.

Handheld Low-level Chemical Agent Detector: TSWG/CBRNC

The Handheld Low-level Chemical Agent Detector project will provide ten prototype chemical detector systems capable of detecting a wide range of chemicals, both industrial chemicals and military agents, at concentrations previously not achievable in the field in a handheld device. The detector will be capable of reliable detection at levels below the required immediately dangerous to life and health (IDLH) and desired time weighted average (TWA). The two-column gas chromatography system shall minimize development risk by miniaturizing and integrating existing benchtop and field capabilities in a battery powered package capable of operating for about eight hours using ambient air as the carrier gas. Using efficient thermal conductivity detectors, the system shall reliably detect and quantify threat chemicals at less than 10 ppb levels. While adequate for most toxic industrial chemicals and some military agents, special sorbent trap and rapid desorption sample concentration methods may be required to measure VX, mustard agents and lewisite. These chemical weapon agents (CWA) have IDLHs

less than 2 parts per billion. Another key technical issue is efficient power management. Intended users for this system include the Technical Escort Unit and Civilian HAZMAT Units. The program was initiated in Q2FY01. The prototype system did not meet user size and detection limit requirements.

Maritime Toxic Industrial Chemical Detector: TSWG

The Maritime Toxic Industrial Chemical Detector project develops a wearable lightweight belt-mounted hands-free device that can quickly alert personnel of undeclared airborne toxic industrial chemicals (TIMs) before adverse acute or severe chronic damage to health results from exposure. The sensor employs an array of incrementally different conducting polymer elements with a dynamically balanced bridge for high resolution and low-noise signals. The energy requirements are less than 1 watt, enabling 8 hours of continuous operation on one "AA"-size battery. The project was initiated in Q3FY03 with the prototype available in Q3FY04.

Other

Immunobead Force Differentiation Assay (FDA): DoD CBDP

The FDA, under development at the Naval Research Laboratory (NRL), is a highly specific and sensitive biosensor capable of measuring antibody-antigen bond forces using magnetic immunobeads. Goals include identifying bacteria, viruses and toxins with 1 ACPLA sensitivity and greater than 99% specificity in less than 15 minutes. Transition opportunities for this technology include JBPDS in FY02.

Amplifying Fluorescent Polymer: (AFP): NIJ, Oklahoma City Memorial Institute for the Prevention of Terrorism

The overall goal of Networked Terrorism Detection System is to develop highly specific approaches for detecting and identifying explosives, nerve gases and BW agents. This development will be applied to produce a continuous, real time network detection system for use against terrorist threats. The approach is based upon utilization of a unique amplifying fluorescent polymer (AFP), which will greatly increase the speed and sensitivity of detecting explosives and CBW agents. The process will focus on producing AFPs that are activated with probes designed for detection of explosives and specific CBW agents. This process will be tested for nitroaromatic and other explosives, a nerve gas agent and three BW agents. The activated AFPs will be incorporated into microarray sensors, which can be integrated into network systems, such as General Atomics E–Smart®, providing continuous monitoring of high value buildings or complexes. Key technology development issues include activation of AFP with chromophore, oligonucleotide and antibody probes in correct chemical and geometric orientation to ensure binding events are transduced to AFP. A prototype microarray sensor is scheduled for Q1FY04. The sensor is envisioned to consist of a complex field of polymer "wells" to which samples will be delivered. Each well will contain a thin film of polymer activated with a specific probe for a particular explosive or CBW agent. The projected end user for the probes is the Air Force E–SMART project. This technology is scheduled to transition into the commercial sector in FY05.

Pyrolysis–Gas Chromatography/Ion Mobility Spectrometry (PY–GC/IMS): DoD CBDP

The PY–GC/IMS is a sensor being developed for both chemical and biological detection. The effort examines the potential for discriminating biological materials at a level of classification higher than "bio" versus "non-bio". This is accomplished by GC/IMS analysis of chemical markers produced upon pyrolysis of biological materials. IMS is already employed in fielded detectors for chemical agents. Transition opportunities for this technology include JBPDS in FY03, PROTECT in FY04 and JSCBD in FY07.

Optical Particle Classifier: DoD CBDP

The Optical Particle Classifier, under development at NRL, is an effort to improve the performance of optical trigger systems. This will be accomplished through exploration of optical parameters, including angular elastic scattering, in addition to fluorescence to differentiate biological particles from other materials that fluoresce. Key parameters being evaluated are particle size and shape as well as fluorescence on individual particles. Transition opportunities for this technology include JBPDS in FY02, PROTECT in FY04, and JSCBD in FY07.

C/B Identification in Water: DoD CBDP

The primary thrust in this area is the development of concepts/technologies to detect and identify contaminants in food and potable water. The traditional threat to the warfighter has been respiratory or percutaneous exposure to CBW agents, but with the change in global politics the threat has expanded to include force protection issues as well as the traditional battle/collateral damage problems. The food portion of this project has been transferred to the medical community.

Lightweight Integrated C/B Point Detectors: DoD CBDP

The longer-term goal of the detection program is to provide technology solutions that decrease the number of individual detectors in the inventory, hence, decreasing the logistics burden associated with maintenance, training and multiple operational concepts. It is also desirable to decrease size and cost of CB detectors. This thrust focuses on conceptualization, development and validation of technologies that provide small, lower cost, point detectors/identifiers that simultaneously address both chemical and biological threats. Transition opportunities include JSCBD in FY07. JFOCs addressed include Contamination Avoidance–Bio Early Warning (CA–BE), Contamination Avoidance–Bio Point Detection (CA–BP), Contamination Avoidance–Chem Early Warning (CA–CE), and Contamination Avoidance–Chem Point Detection (CA–CP).

Distributed Chemical Agent Sensing and Transmission System: TSWG

The Distributed Chemical Agent Sensing and Transmission System (DICAST) bridges the gap between point detection capabilities and stand-off detection systems by fielding chemically sensitive optical fibers for six different chemical agents that can be strung around a facility perimeter or inside a building to provide area monitoring and alarm capability. This requirement will be addressed by deploying multiple point sensors, each sensor then reporting through the network to a command and control station. The sensing capability is integrated into environmentally sound cables. The optical sensing approach provides rapid detection and immediate warning when the sensor cables are exposed to chemical agents. The project builds on earlier SBIR and DARPA research efforts. TSWG initiated this effort in Q2FY03. Two prototype systems will be available in Q1FY05.

Reagents/Assay Development

Bio-contaminant Detection and Identification Strategies: TSWG/CBRNC

Monitoring to detect the presence of intentionally released bio-contaminants requires an established monitoring protocol for use in non-battlefield scenarios. This research compares sample collection and sample preparation strategies, and develops a monitoring protocol for quantitative assay for the detection of three biological simulants in the air and on a variety of common office surface materials. Technical obstacles include reduction of test chamber sampling results to simple "rules of thumb" analogous to those used in radiological controls surface sampling. Intended users include the military and civilian response personnel. The program was initiated in FY00. Initial Sampling Guidelines are available, and work has been extended based

on new user requirements to evaluate additional sampling kit designs and the impact of chlorine dioxide decontamination treatment on sample recovery and analysis through Q4FY03.

Nucleic Acid Based Assays: DOE CBNP

This R&D effort is part of the DOE Biological Foundations program. The overall objective of Biological Foundations is to provide an integrated body of biological information and tools as a foundation for CBNP. Expected nucleic acid based capabilities generated from these programs include:

- Development of tools and methods for rapidly identifying and isolating unique DNA in an organism to, over time, reduce the cost and time of signature development by more than a factor of 100
- Production of whole-genome DNA sequence data for key pathogens and their nearest neighbors as a resource for signature development
- Development of informatics tools to facilitate the development, sharing, utilization and archiving of pathogen DNA sequence signatures

Nucleic Acid Based Assays developed in this program will be subsequently tested in the DNA Reagents Testing and Validation, Critical Reagents, BASIS and Bioforensics Acquisition/Transition Activity programs.

Reagent Development (Antibodies and Alternatives): DoD CBDP

The purpose of this thrust is to develop new methodology to either greatly enhance the existing set of reagents that would impact, by at least an order of magnitude, the overall system performance (cost, logistical burden, etc.) or to develop reagents that cannot be produced via the current set of available methodologies. The goal is to expand the current set of fielded capabilities in biological detection/identification to address the full threat list. Targeted mature development programs are JBPDS Blk II and Critical Reagents Program (CRP). This effort is being performed by a number of laboratories. One primary focus is to explore and utilize genetic recombinant techniques for the production of specific antigen-binding antibody fragments to antigens of high priority in biological defense. Research on multivalent assays is also ongoing. Biased libraries, generated from immunized animals, or unbiased random combinatorial libraries serve as the principal supply of antibody clones. At present, the major focus is on biased libraries. Candidate recombinant antibody fragments are implemented in ELISA, HHA and other immuno-biosensor platforms for comparison of efficacy with established reagents. Candidates showing high potential are submitted to the CRP for validation and employment in fielded sensors. Ongoing efforts in this program are taking place at a number of locations including ECBC and NMRC. The JFOC addressed is Contamination Avoidance–Bio Point Detection (CA–BP).

Immunoassays for Threat Bacteria and Toxins: DOE CBNP

Immunoassay uses antibodies (Abs), proteins that have strong binding affinity for certain proteins on antigens. This work will focus on using an "eTag" implementation of the assay developed by ACLARA BioSciences to perform solution-phase multiplexing. The reaction products are analyzed by capillary electrophoresis (CE) with single-color detection. This assay is able to detect all three types of pathogens (bacteria, viruses, and protein toxins) with good sensitivity and selectivity. Efforts will include developing binding antibodies, binding scissors, photo activation, and separation techniques.

Protein Signatures of Threat Toxins: DOE CBNP

Work will focus on protein signature assay which uses a due to label amino acids on proteins that are then separated and analyzed by capillary electrophoresis (CE). This assay has

the advantage of producing a signal for unexpected proteins which would be missed by the more selective and sensitive immunoassay. This assay would also corroborate the immunoassay results for targeted antigens. Efforts will include developing labeling, pre-concentration, and separation techniques.

Supporting Technologies

Ambient Background Characterization: DoD CBDP–DOE CBNP

Ambient background characterization is an effort to collect representative background samples as well as to develop a set of heuristics describing the background that may be encountered by detectors in field application. The project is a joint CBDP–CBNP task in collaboration with The Technical Cooperation Program (TTCP) member countries and leverages the prior collection of background data from various sites around the world by a number of programs. The project is scheduled as a two-year effort completing in FY01 with planned follow-on to collect additional data to fill identified gaps.

Aerosol Samplers: DoD CBDP / DOE[6]

Basic aerosol technology provides a capability to generate and characterize standard test aerosols and CB simulant aerosols in the field and in laboratory facilities—including chambers and wind tunnels. This aspect of the aerosol technology program is focused on quantitative analyses of aerosols to provide the contamination avoidance commodity area with systematic quantification of developmental aerosol collectors and their inlets, in order to accelerate the hardware development process. It also provides well characterized aerosol challenges to support standoff detection development. Near-term investments are being implemented in a wind tunnel capability for a wide range of challenge aerosols at speeds up to 60 mph. A second area of emphasis is aerosol collector technology. This includes the design of improved aerosol inlets processing elements such as ducts, concentrators and size-selective devices (*e.g.*, impactors and cyclones), and collection devices for the aerosol particles. Transition opportunities for these technologies include JBPDS and JSCBD.

Threat Agent Characterization: DoD CBDP

Investments are being made in the characterization of the properties of threat agents. Emphasis is also placed on developing appropriate simulants for use in the RDT&E process. Execution and funding of the work are integrated across Non-Medical, Medical and DOE performers and coordinated with the Intelligence Community. Deliverables from this program are technical data on threat agents and simulants for developmental and operational testing.

[6] DOE funding not included in the CBNP budget.

APPENDIX B

Acquisition/Transition Activities Involving CB Decontamination Technologies

The transition and acquisition activities to which CB decontamination research and development programs and DoD and DOE make significant contributions are introduced below.

Sorbent Decon System: DoD CBDP

The purpose of this program is to develop an immediate decontaminant that is superior to the XE555 carboneous and ion exchange resin mix previously used in the M295 kit. The new adsorbent eliminates DS-2 from the operator's spraydown procedures. The key requirements for the sorbent are a reduction in off-gassing and contact hazard associated with the adsorbent after use when compared to the M295 kit. The DoD CBDP tested Solid Phase Chemistry technologies in the Sorbent Decon System during FY00 and is currently fielding the M-100 Sorbent Decon Kit using aluminum oxide-based sorbents developed during this effort.

Modular Decon System: DoD CBDP

The Modular Decontamination System (MDS) program was initiated to provide the soldier with a vastly improved capability to perform detailed equipment decontamination on the battlefield. The Army's experience during Operation Desert Storm validated the need for a more deployable system and for the more efficient use of water, a scarce resource in an arid environment. The M22 High Pressure Washer (HPW) delivers hot pressurized water up to 3,000 psi at a rate of 5 gpm through two spray wands. This washer can also dispense a high-volume (40 gpm) flow of cold water and, through an injector, liquid detergents. Its accessories include the necessary hoses, wands, nozzles, hydrant adapters, and injector. The M22 high-pressure/hot water module can draw water from natural water sources and dispense it at variable adjustable pressures, temperatures, and flow rates. The hydrant adapters provide a capability for using urban water supplies. It can also be operated from a trailer. First Unit Equipped is scheduled for FY02, and Initial Operational Capability is scheduled for the end FY03.

Joint Service Sensitive Equipment Decontamination Program (JSSED): DoD CBDP

The purpose of this program is to develop CB decontamination systems which can be used on small equipment items and interior spaces. Block I will develop decon systems that can decontaminate small equipment items, electronics, optics, or components that may be easily damaged by current decontamination methods. Block II will develop the capability to decon interior spaces such as the interior of aircraft, ships, vehicles, and mobile communication stations, all of which contain a multitude of surfaces and electronic components. Block III will focus on decontamination of Phase II interiors while on the move. CBDP JSSED testing, during FY02 and FY03, include technologies from Solid Phase Chemistry and Sensitive Equipment.

Joint Service Family of Decon Systems (JSFDS): DoD CBDP

The purpose of this program is to develop a family of CB decontamination systems and application systems for both equipment and wounded personnel. **Block I** will evaluate, review, and test NDI, COTS and mature technology decontaminants, and field those that meet the requirements of the Joint Operational Requirements Document (JORD) for use at fixed facilities, ports of entry, airfields, logistics nodes and key command and control centers. **Block II** will develop a family of decontaminant applicator subsystems that will be capable of dispensing the selected family of decontaminants. **Block III** will develop decontaminants and applicators for skin/casualties with open wounds. Technologies under consideration for this program include

DF-200 from Sandia National Labs and developed as part of the CBNP program and Decon Green from DoD's CBDP program.

Next Generation Decon Kit: DoD CBDP

The purpose of this program is to develop a solids-based decon system for use in immediate and operational decon operations. This kit is a follow on sorbent program that will have greater reactivity than the Sorbent Decon System and will be effective against both chemical and biological agents. CBDP Next Generation Decon Kit testing will include technologies from DoD Solid Phase Chemistry in Q1FY11.

Superior Decon System: DoD CBDP

The purpose of this program is to develop a single, multi-use organic, aqueous-based, or mixed organic/aqueous decontamination solution to replace DS2 and aqueous bleach (STB and HTH) in thorough decon applications. This program will also develop applicator systems for use by mobile forces that are capable of dispensing the new decon solution. CBDP Superior Decon System testing will begin in Q1FY11 include technologies from DoD CBDP Solution Chemistry efforts.

Domestic Demonstration and Application Programs

Program for Response Options and Technology Enhancements for CB Terrorism (PROTECT): DOE CBNP

Special requirements for decontamination and restoration of subway service after a chemical incident have emerged from discussions with the Washington, D.C. and Boston subway staffs. Contacts with the National Medical Response Teams (NMRTs) have led to discussions of subway needs versus NMRT chemical agent decontamination capabilities. This information is also being coordinated with CBNP decontamination researchers. Decontamination plans for the subway systems have evolved considerably, with only a few technical and administrative issues remaining. Negotiations are underway to include decontamination technologies in PROTECT demonstrations. The program timeline for PROTECT is FY00–04.

Restoration: DOE CBNP

The events following discovery of B. anthracis-laden letters on October 4, 2001, demonstrate that this country is not prepared to effectively deal with the problem of clean-up and restoration of facilities that have been contaminated with biological agents. Some of these facilities remained closed nine months later, and the restoration operations have been slow, costly and controversial. These efforts have been hampered, in part, because there is no consensus on the critical aspects of such an operation including appropriate decontamination methods, clean-up standards or verification processes. This state of affairs suggests that an attack against key transportation nodes such as major airline hubs would have widespread and lasting impact on this nation's travel industry and could cause serious social and economic disruptions.

The goal of this proposal is the development and demonstration of restoration plans and architectures for airports and other public transportation facilities. In particular, the focus will be on approaches that can be implemented in the near term to allow early resumption of essential operations. By developing and vetting such plans before an incident occurs, it will be possible to avoid some of the delays and inefficiencies that have been all too common during recent restoration operations.

Thermal Decon: DoD CBDP

This project leverages several hot air decon studies done by ECBC and DPG and is attempting to validate thermal decontamination using forced hot air as an approach to meet the

requirements for JSSED Block II. In early FY03, modeling efforts using droplet evaporation models indicated that thermal approaches might be useful for decontamination of a large subset of chemical agents. Plans for 3QFY03 include field studies at AMARC on a decommissioned C-141B aircraft designed to demonstrate the ability to heat up aircraft interior surfaces and control temperature so as not to damage sensitive interior components. In addition, laboratory testing will determine the time required to decon various interior aircraft surfaces at the appropriate temperature and flow rates projected for use inside the aircraft. This overall effort will culminate with simulant testing on coupons placed at appropriate locations within the aircraft and treated with hot air and will be completed at the end of 3QFY03.

Restoration of Operations (RestOps): DoD CBDP

The Restorations of Operations Advanced Concept Technology Demonstration (ACTD) will demonstrate those actions taken before, during and after an attack to *protect against* and *immediately react* to the consequences of a CB attack. These actions aim to restore operating tempo (OPTEMPO) in the execution of the mission and in the movement of individuals and materiel to support combat operations at a fixed site. One goal of this ACTD is to generate improved chemical and biological warfare detection technologies in an effort to reduce vulnerabilities at a fixed site. Candidate technologies will be tested during Joint Chemical Field Trial testing at DPG and subsequently down-selected for further testing during the ACTD. In addition to providing technology transition opportunities for CB detection, Protection and Medical commodity areas, RestOps also offers prospects for Decontamination technology transition. RestOps decontamination testing was executed in the Joint Chemical Field Trials (JCFT) during FY00 and FY01. The roadmap shows possible candidate R&D technologies for transition into RestOps to include DF–100/200 and L–gel. The ACTD is currently scheduled to end at the end of FY03 followed by two years of residual support at Osan Airbase.

Contamination Avoidance at Seaports of Debarkation (CASPOD): DoD CBDP

Seaports of debarkation (SPODs) are recognized as critical assets for power projection and force deployment operations, making them attractive targets for exploitation. Unified Combatant Commanders have responsibility to defend SPODs against terrorist or other adversary CB, Toxic Industrial Chemical (TIC) or Toxic Industrial Material (TIM) attacks/releases. The CASPOD ACTD will leverage work done in other projects (Seaport Protection Analysis (SPPA) project and the RestOps ACTD) to identify and provide technologies, capabilities and procedures that can be utilized prior to, during or after an attack/release to mitigate effects on time phased force deployment data (TPFDD) flow. Operational concepts and TTPs to initiate and sustain CB and TIC/TIM defense operations at SPODs will be demonstrated. The force structure necessary to implement procedural and equipment requirements will be identified and refined. A resident/pre-positioned or rapidly transportable CB and TIC/TIM defense equipment and material packages needed for employment at SPODs will be developed and demonstrated. Strategic operational improvements/shortfalls for CASPOD contingencies will be identified. In addition, a forum, process and structure for addressing and modifying U.S., coalition and host nation policy issues will be provided. The ACTD demonstration phase is currently scheduled from FY02–04, with transition occurring in FY05–06. The roadmap shows possible candidate R&D technologies for transition into CASPOD to include DF–100/200, L–gel and Decon Green.

LFADD: DoD CBDP

The purpose of the Large Frame Aircraft Decontamination Demonstration is to identify methods of decontamination sufficiently effective to clean contaminated aircraft and allow their timely return to full, unrestricted use in the US. This requirement goes well beyond any type of "operational decontamination" and is not envisioned to be done in-theater, but at some type of transload location. The demonstration is sponsored by PACOM and is scheduled for FY02 at

Eglin AFB. It will consist of evaluating large frame, military cargo aircraft chemical warfare agent decontaminants. The most effective procedure to use for each decontaminating material will be determined along with the necessary logistic support. Analytical methods that can be used in the field to determine residual aircraft contamination will also be determined. Data collected, assessments and conclusions may be used by the USAF in establishing tactics, techniques and procedures (TTPs) for decontaminating exterior and interior aircraft components. Data may also be used to facilitate the establishment of new policies regarding use of previously contaminated aircraft (PCA). LFADD is strictly focused on chemical contamination rather than biological contamination. In those cases where an extrapolation can be made to biological contamination, results will be documented. Roadmap technologies tested for inclusion in LFADD were Sandia Foam (DF–100/200) and Environmentally Friendly Solvents.

Test/Validation

Joint Field Trials/Lab Tests/TRE: DoD CBDP

The purpose of the JPO–BD JFT program is to evaluate new and existing technologies for incorporation into biological defense programs. JPO–BD sponsors a JFT test once a year in which developers provide test items that are evaluated by analysis teams. This roadmap includes the testing of several technologies. Successful technologies are subsequently matured for integration into detection systems. Program timeline initiates in FY98 and has no termination. The majority of Sensor/System R&D program items take place in JFT testing at some time (see roadmap).

Within the JFT are the Joint Chemical Field Trials (JCFT). This testing is being sponsored by the Defense Threat Reduction Agency in an effort to facilitate the identification of technologies that will be utilized in the RestOps and CASPOD ACTDs. JCFT testing was held at WDTC, Dugway Proving Grounds, from 2QFY00 through 2QFY01. Once technologies have been technically evaluated in JCFT, they will subsequently be analyzed in operational testing for military utility. Successful technologies will eligible for acquisition.

Decontamination Field Trials: DOE CBNP

These trials are focused on the bio-decontamination of office materials that have been contaminated with bacteria. They have been separated into three areas, Phase I, Phase I Follow on and Phase II. Phase I testing involved a number of candidate technologies that were tested for bio-decontamination utility on office materials. Testing was executed at Dugway Proving Ground in FY99. Phase I follow on testing will evaluate ten additional technologies that have been identified with potential bio-decontamination applicability. Testing is scheduled for FY02 and will utilize the original Phase I panel test format to evaluate the efficacy of these additional technologies. This testing format consists of 16x16 inch panels made from typical office materials such as ceiling tile and carpet. Panels are contaminated with *Bacillus globigii* bacteria spores, allowed to equilibrate and then decontaminated using the candidate technologies. Evaluation is made based on the technologies' ability to reduce the spore residual to less than or equal to 500 spores per square meter. This test format allows a direct comparison of bio-decontamination technologies. Phase II testing in FY01 investigated the bio-decontamination of office materials, with an operational rather than technical approach.

Building Decon Environmental Technology Verification: EPA

The performance of alternative commercial or near-commercial building decon technologies will be determined under standardized conditions as part of EPA's Environmental Technology Verification (ETV) program. Test protocols will be refined over time, and decon technologies selected for testing, based in part on data obtained from the Decontamination Parametric Analysis (Supporting Technologies).

Special Event

Crisis Deployment: DOE CBNP

Description not available at time of printing

Decon Urgent Need Development: DoD CBDP

In late FY02, U.S. Central Command issue an Operational Needs Statement (ONS) for an interim decontaminant to replace DS-2. The Joint Requirements Office validated the need for an interim decontaminant and issued an Urgent Needs Statement (UNS) in September 2002. In response to the ONS, DoD began rapid developmental and operational testing of DF-200, a commercially available decontaminant developed by Sandia National Labs. This testing defined the operational capabilities of DF-200 and allowed interim fielding of the product to deployed forces for use under defined conditions. This testing began in first quarter FY03 and continued throughout the fiscal year and included testing of not only the DF-200, but also specialty applicator systems for equipment and wide-area decontamination operations.

Guidance

Areas for Capability Enhancement (ACEs): DoD CBDP

The ACEs are established by the Counterproliferation Program Review Committee (CPRC). The ACEs were established to characterize those areas where progress is needed to enhance both the warfighting capabilities of the Combatant Commanders (COCOMS) and the overall ability to satisfy the demands of U.S. counterproliferation policy. A detailed discussion of each ACE along with agencies' programs to support each ACE can be found in the 2003 CPRC Report on Activities and Programs for Countering Proliferation and NBC Terrorism. The ACEs provide broad guidelines for R&D/acquisition investment and prioritizes areas where additional capabilities are required to meet the challenges posed by WMD proliferation threats. There is one ACE that addresses decontamination (DoD ACE Priority 3: Enable sustained operations in a WMD environment through decontamination, and individual and collective protection); these programs support that ACE. The ACEs timeline is unlimited.

Joint Future Operational Capabilities (JFOC): DoD CBDP

JFOC was established by the Joint Service Integration Group in an effort to identify and prioritize Joint User far-term future operational capabilities as expressed in the emerging Joint NBC Defense Concept. The overall intent is to provide enhanced user guidance to the Joint NBC Defense Science and Technology (S&T) community to assist in the NBC S&T program formulation and execution process. Prioritized Joint Future Operational Capabilities include:

- Contamination Avoidance[7]
- NBC Battle Management
- Individual Protection
- Restoration Capability[8]
- Collective Protection

A detailed description of JFOC can be found in the NBC Defense Annual Report. The JFOC timeline is unlimited.

[7] Point and Standoff Detection are included within the JFOC definition of Contamination Avoidance.
[8] Decontamination is included within the JFOC definition of Restoration Capability.

Building Decon Guidance: EPA

Available data on the performance of building decon technologies will be evaluated, including a thorough evaluation of the field experience in decontaminating the Federal buildings contaminated during the 2001 anthrax mail attack. An engineering and economic analysis will be conducted of building decontamination, as a function of building characteristics and the nature of the CB attack, based on this practical experience. Technical guidance will be prepared to assist building owners, on-scene coordinators, governmental agencies, and other users in selecting the most appropriate decon approach (and the most appropriate manner of implementing that approach), depending on the characteristics of the particular building of concern to the user. This guidance will be updated as further information becomes available through the Decontamination Parametric Analysis (Supporting Technologies) and the Building Decon ETV (Special Event).

Chem-Bio Decontamination: Research and Development Programs

Solution Phase Chemistry

The goal of this thrust area is to develop decon systems that supplement or replace existing systems used for immediate, operational, and thorough decon against both chemical and biological agents. Organic or aqueous-based decontamination solutions will be developed to replace DS-2 and aqueous bleach in thorough decon applications by identifying, stabilizing, and optimizing the chemistry of candidate systems and developing means to reduce logistical burdens associated with the operational decontamination. Emphasis areas (see below for specific CBDP program details) include oxidative chemistry, enzymatic and catalytic decon, and formulation development. Leveraging efforts include DF-200 (Sandia foam) and vaporized hydrogen peroxide (VHP).

Enzyme Decon (Biological): DoD DARPA

The objective of this multi-effort program is to develop an enzyme-based catalytic decontaminant that will be non-toxic, non-corrosive, and environmentally safe. The decontaminant will consist of a variety of enzymes; proteins, peptides and other natural products; and stabilizing materials (buffers, etc.) that will be initially packaged in a dry form for easy reconstitution with any available water. It will be disseminated with currently available or planned decontamination systems, fire-fighting equipment, or other types of sprayers (e.g., aircraft deicing equipment or wash-racks, shipboard wash-down systems). The decontaminant is intended for use in all situations where some water can be tolerated, from small-scale operations (personnel and personal equipment) to operational vehicles and equipment to large-scale fixed sites (airbases, ports, logistics nodes, and civilian areas). The major project within this effort was DTO CB.09 (completed in FY02) that dealt specifically with the classical chemical warfare agents (G- and V-type nerve agents and sulfur mustard). Other efforts outside of the DTO include enhancing and broadening the catalytic properties of several nerve agent degrading enzymes, identifying/creating enzymes capable of catalytic detoxification of GV and other less common agents, and combining CW and BW materials into a single product. The program will transition to JSFDS as a product improvement.

Solution Chemistry: DoD DARPA

The focus of the DARPA Solution Chemistry Program is to develop nanomaterials that will serve as antimicrobial agents that can also be used as BW decontaminants. Nanomaterials development is modeled after the immune system in that nanomaterials also involve redundant,

non-specific and specific forms of pathogen defense and inactivation. The first nanostructure is an emulsion containing vegetable oil, surfactants and solvents. This material is less than 500 nm in diameter and can be stored for prolonged periods of time without special precautions. The nanoemulsion inactivates bacteria, viruses, fungi and spores through size-dependent disruption of the organism, but is non-toxic. The lack of toxicity also allows this material to function as a pathogen avoidance barrier and post-exposure therapeutic agent applied in a topical manner to wounds, skin and mucous membranes. This material has been field tested as a decon agent and found to reduce Bacillus spore count by a million fold over a 24 hour period. It has also been effective in treating wounds contaminated with either Bacillus or Clostridial spores. The DARPA Solution Chemistry program was completed in FY01. Research was performed at the University of Michigan. The program transitioned to USAMRIID in FY01 and is scheduled to transition to JSFDS (Blk III) in FY03.

L–gel (Peroxymonosulfate Oxidizer): DOE CBNP

The LLNL peroxymonosulfate research is focused on the evaluation of various oxidizer systems as reagents to allow for CB agent detoxification and/or degradation to nontoxic, environmentally acceptable components rather than necessitate complete destruction. In order to maximize the contact time between the decontaminating reagent and the contaminant agent, gelled reagents were selected as the primary carrier material. Gels have the additional advantage of adhering to vertical and even the underside of horizontal surfaces such as ceilings and walls. The primary decontamination system now under development at LLNL is based on the commercial oxidizer "oxone" manufactured by DuPont. The active ingredient is potassium peroxymonosulfate. LLNL's work built on previous research at Edgewood Chemical and Biological Center (ECBC), which demonstrated the effectiveness of aqueous Oxone in decomposing both VX and Mustard type agents. Experimental testing on both surrogates and real chemical agents has further shown that only RO• (peroxyl) oxidizers are effective for complete CW decontamination. This formulation was also found to be effective for all BW spore surrogates as well as live vaccine strains (*B. anthracis* Sterne). To date, the gelled system has successfully been tested with a complete suite of CW and BW surrogates. ECBC has been involved in the laboratory evaluation and field testing of L–gel. Real CW agent testing has been completed by ECBC where L–gel was found to reduce VX, HD and GD below detectable limits on all surfaces tested. L–gel was tested in FY99–00 during the Decontamination Field Trials, FY00 during the Fixed Site Decon Trials (CBDP Miscellaneous Testing) and in FY00–01during RestOps ACTD. During FY00 all laboratory and field testing was finalized on live CW and BW agents. Tests also demonstrated L–gel to be effective against the biological toxin surrogate ovalbumin. The roadmap shows FY02 transition opportunities for L–gel to include the Superior Decon System, CASPOD and the commercial sector.

DF–100/200 (Sandia Foam): DOE CBNP

A non-toxic, non-corrosive aqueous foam with enhanced physical stability for the rapid mitigation and decontamination of CBW agents has been developed at SNL. This technology is attractive for civilian and military applications for several reasons. It requires minimal logistics support, and a single decon solution can be used for both CW and BW agents. Mitigation of agents can be accomplished in bulk, aerosol and vapor phases, and it can be deployed rapidly. The technology exhibits minimal health and collateral damage and is relatively inexpensive. It also has minimal run-off of fluids and no lasting environmental impact. The foam can be delivered by various methods. One preferred method is based on an aspiration, Venturi effect, which eliminates the need to pump additional air into a closed environment and minimizes the transport of CBW agents to uncontaminated areas. Results to date have shown effective decontamination of both CW and BW agent simulants and live agents on contaminated surfaces and in solution. More recent results have shown that the foam effectively kills anthrax spores and

successfully neutralizes TGD (thickened soman), VX and HD. The foam was demonstrated in the Fixed Site Decon Trials at the Edgewood Chemical Biological Center (ECBC) in FY99–00 (shown as DOE Miscellaneous Testing). The foam was also demonstrated at the Decontamination Field Trials in FY99–00 and during RestOps ACTD in FY00–01. The formulation has been successfully deployed through spraying and fogging devices in preliminary experiments. The FY01–02 primary efforts are foam optimization, further engineering of foam deployment systems, technical support to our commercial partners, field testing in both civilian and military settings and alternative deployment methods (i.e., spray applications).

Environmentally Friendly Solvents: DoD CBDP

The objective of this program is to develop the ability to successfully decontaminate sensitive equipment without adversely affecting its operational readiness, reliability, or maintainability. In the mid-1990s new non-ODC substitute solvents were perfected and marketed. Paralleling the development of the new solvents were major advances in the field of precision cleaning equipment. This project is exploiting the progress made in solvent chemistry and precision cleaning hardware for sensitive item decontamination. In addition, a spot decon system using these solvents with suspended metal oxides will also be explored. The program is scheduled for JSSED Blk I testing in Q2FY02 and projected to transition to JSSED Blk II/III by Q4FY04.

Enzyme Decon (Chemical): DoD CBDP

The objective of DTO CB.09 is to develop an enzyme-based, chemical-only catalytic decontaminant that will be non-toxic, non-corrosive and environmentally safe. The decontaminant will consist of a variety of enzymes, chemical catalysts or reactants and stabilizing materials (buffers, etc.). It will be packaged in a dried form and easily reconstituted with any available water. It will be disseminated with currently available or planned decontamination systems, fire-fighting equipment or other types of sprayers (e.g. aircraft deicing equipment or washracks). The decontaminant is intended for use in all situations where some water can be tolerated, from small-scale operations (personnel and personal equipment) to operational vehicles and equipment to large-scale fixed sites (airbases, ports, logistics nodes and civilian areas). Other efforts outside of the DTO include enhancing and broadening the catalytic properties of the wild-type enzyme phosphotriesterase (PTE) to improve hydrolytic detoxification and detection of the G- and V-type nerve agents and their associated analogs. In addition, efforts are underway to find enzymes capable of hydrolytic detoxification of GV and other less common agents. The roadmap shows transition opportunities for this technology to include the Superior Decon System in FY06.

Oxidative Formulations DTO: DoD CBDP

The objective of this DTO is to develop a non-corrosive, material compatible, non-toxic and environmentally friendly oxidative CB decontaminant to replace DS2 and STB/HTH. This DTO will consist of four main R&D efforts (below): Decon Green, Surfactant Based Decontaminating Solution, Dioxiranes, and Solid Water (L-gel). An oxidative formulation will be effective against chemical and biological warfare agents. Since this effort uses a formulation approach, it will potentially allow for the incorporation of enzymes and polymeric catalysts (DTO CB.09), a DARPA-developed bio decon product, and other reactive technologies into one formulation with a peroxy-based oxidant serving as the primary reactive component. Multiple reactive components in a pH range of 7.5-9.0 will allow either oxidation or displacement reactions that yield acceptable reaction products. Water-soluble components and simple *in-situ* mixing will make the formulation compatible with existing military or COTS decon applicators. The DTO began in Q1FY02 and ends at Joint Service Family of Decontamination Systems transition in Q4FY06.

Decon Green: DoD CBDP

Decon Green will be a universal decontaminant for VX, GD, and HD based on relatively non-toxic, environmentally acceptable materials such as baking soda, hydrogen peroxide, and a co-solvent. All materials are commercially available within a broad industrial base. The product will be two solutions plus a catalyst that can be easily mixed using multi-component mixing/storage system. The decontaminant will be an organic system that can be used with fielded decon equipment or COTS high pressure sprayers. The current Decon Green formulation combines hydrogen peroxide with a co-solvent and catalyst to provide an effective broad based organic decontaminant effective against chemical and biological warfare agents, as well as being relatively non-toxic and considerably less corrosive than current decontaminants. Another distinct advantage of this decontaminant is that it will not freeze at sub zero temperatures (down to -31°C), nor will its effectiveness decrease due to high temperatures (up to 49°C).

Surfactant Based Decontaminating Solution: DoD CBDP

The objective is to develop a replacement for the current decontaminating solutions (DS2 and HTH) with a chemical and biological agent decontaminating (decon) solution utilizing two technologies, surfactant (microemulsion) and peracid chemistry, that will meet the need for an effective dual use decon solution that is noncorrosive to materials and does not present a hazard to the user or the environment. Microemulsions afford a means of dissolving the organic chemical agents and inorganic, reactive decontaminating components in one solution, without the need of environmentally unfriendly solvents. Microemulsions also have very low interfacial tensions that will enhance their ability to sorb into agent-contaminated coatings to bring the reactive decon components into contact with the chemical agents. The peracid precursor offers a unique means of incorporating an environmentally friendly, strong oxidizer, that is reactive at a mild pH (noncorrosive to materials), into the decon solution. The peracid eventually breaks down into the weak acid and water. There are many forms of the peracid precursor, used in the laundry industry, with varying solubility and surface active properties. A solid form of peracetic acid is currently being incorporated into the decon formulations. This material provides the shipping, storage, and handling advantages of a solid peracid. Although not as far along as Decon Green in its development cycle, initial efficacy results for the Surfactant-Based Decontaminating Solution on chemical and biological agents appear very promising.

Dioxiranes: DoD CBDP

The objective of this effort is to explore the effectiveness of dioxiranes as a decontaminant for chemical and biological warfare agents. This effort will determine the stoichiometry and kinetics of reaction of dioxiranes with simulants representing the main classes of chemical (H-,G-, V-agents) and biological (bacteria and their spores) agents and identify the products of reaction. Initially, dimethyldioxirane (DMDO) will be used for proof of concept; however, longer alkyl chains may be required for safety and environmental reasons. Positive results will be confirmed by reaction with active agents, and conditions for practical use as a decontaminant will be defined. Dioxiranes constitute a new class of powerful oxidants and have been used (mainly DMDO) extensively as powerful oxidants capable of carrying out a variety of synthetically useful oxidations under mild conditions. To date, the dioxirane effort has shown that these oxidants are very effective against biological agents and a limited test bed of chemical warfare simulants. The ultimate goal of this effort is to provide a viable component for the superior decon formulation effort described below.

Solid Water (L-gel): DOE CBNP

The L–gel effort also includes a "Solid Water" aerosolized form of the liquid decontaminant for use in ventilation ductwork or other confined spaces. Based on the Dry Water concept developed by DeGussa Corporation, nanoparticles of hydrophobic silica are produced

and then used to coat aerosolized water droplets, capable of delivering 80–95% 1N oxone solution directly to chemical agents. Preliminary results demonstrate decontamination of CW surrogates in 30 minutes. L–gel Solid Water transition opportunities include the Superior Decon System and the commercial sector at the end of FY04.

Electrostatic Decontamination System (EDS): TSWG CBRNC

The objective of this TSWG Task is to develop and test a field prototype decontamination system using a battery operated man-pack photo-activated liquid decontamination system for chemical and biological (CB) agents and persistent toxic industrial chemicals (TICs). The system comprises an intense, pulsed, lightweight, portable, battery powered Ultraviolet (UV) Light Source Unit and a Photosensitizer Sprayer Unit. The EDS uses a photosensitized UV process with electrostatic spraying for efficient low-drift loss photosensitizer application. The UV activation of the photosensitizer results in significant improvement of the kinetics and effectiveness of the decontamination reaction. The laboratory validation of the preliminary system design will be completed to include evaluation of the EDS effectiveness against simulants and actual CB threat agents. The preliminary design and laboratory evaluations will provide technical data for the final design, 'rapid prototyping' and testing of the field prototype EDS. This program began in Q3FY02, with final design review in Q4FY02, the field prototype evaluation began in Q1FY03. Expanded testing in response to user requirements will occur in Q3FY03 with commercial transition in Q1FY04.

Enzyme Aerosol Fog: DOE CBNP

The objective of this research is to develop and optimize an integrated decontamination system of three key components. The first component is aerosol for generation, based on the patented technology of Encapsulation Technologies. The second component is enzymatic decontamination or deactivation of chemical hazards, including chemical warfare agents. The third component is biocide application for deactivation and mitigation of pathogenic hazards, including biological warfare agents.

It is anticipated that this technology could be used in a variety of applications, including chemical and biological attacks on fixed sites, aircraft, and other sensitive equipment; protection of American embassies abroad; cleanup of buildings by hazardous materials response teams following an attack; in hospitals and by emergency medical care teams.

Solid Phase Chemistry

The intent of this thrust area is to investigate and validate cost effective deactivation and destruction of CW agents rapidly by solid matrices, extending the technology to areas beyond sorbent decon. The reaction chemistry of agents with novel nanomaterials is a component of this thrust. Emphasis areas include: reactive nanoparticles, reactive decon coatings. Leveraging efforts include: DARPA MURI efforts and Nanoscale Materials Incorporated (NMI) efforts. Testing of Solid Phase technologies is described above in Sorbent Decon System, JSSED Blk I, and Next Generation Decon Kit.

Destructive Adsorption: DoD CBDP

This program will develop the next generation of reactive sorbent for operator spray-down and personal wipe-down procedures in immediate decontamination. The operational advantage of immediate decontamination is that it prevents the contamination of clean areas through transfer of agent by eliminating any liquid agent from the surfaces that the soldier must touch during the performance of his mission. The sorbent may be suitable for skin decontamination, but this is not a development direction. The primary approach is to prepare, characterize and evaluate nanosize metal oxides and core/shell metal oxide systems, however,

functionalized polymers and metal exchanged zeolite are also being investigated. Specific goals are to increase the reactivity of the sorbent, increase the reactivity capacity, increase the decontamination efficacy, and reduce the off gassing hazard from spent sorbents. Three primary technology approaches are being considered. The first includes nanocrystalline MgO, alumina and other sorbents prepared by the classical sol-gel method and/or by a modified method. Iron oxide (or other metal oxides) will also be applied to the nanocrystalline structures by using a non-aqueous impregnation technique to provide a second category of sorbents. The second approach will study the reaction of CW agent simulants on microcrystalline aluminum oxide coated with multi-layers of metal oxides [oxides of copper (II), iron (III), and manganese (III)]. The third approach consists of metal exchanged zeolites prepared using conventional methods and characterized by surface analysis techniques. The materials will be challenged with drops of agent and the reactions followed by FTIR and/or MAS NMR. These technologies will transition to the Next Generation Decon Kit.

Gas Phase Chemistry

The goal of this thrust area is to develop gaseous solvents that have superior solubility for chemical agents while also meeting safety, health environmental, and material compatibility requirements. Although technically not a gaseous phase product, plasma based systems form a subset of this area. Emphasis areas include reactive gases, plasma-based systems, supercritical carbon dioxide. Leveraging efforts include the LANL Atmospheric Pressure Plasma system and the DARPA chlorine dioxide effort.

Reactive Gas Phase Reagents: DOE CBNP (LANL)

This work is focused on investigating the use of gas-phase ozone and chlorine dioxide systems for CBW decontamination. While liquids, gels and foam-based reagents should be effective in decontaminating exposed surfaces, reactive gases will be necessary to "complete" a full decontamination since gases are the only practical means of getting into small cracks, cul-de-sacs, micro-porous materials and air ducts. Gaseous ozone demonstrated, under the right environmental conditions, to be an effective reagent against biological agent surrogates in as little as one-half hour. Bacterial spores appear to be slowly dissolved upon contact with ozone. Times on the order of a day or two may be required for the most persistent chemical agents. For releases within civilian facilities, these times are still believed acceptable. Studies using other candidate gases (for example, chlorine dioxide) will be initiated. Results will be correlated into a form suitable to responders & planners in order to provide the best strategy for a given scenario. This technology is planned to transition into the commercial sector at the end of FY02.

Atmospheric Pressure Plasma Jet (APPJ): DOE CBNP

The objective of Atmospheric Pressure Plasma Jet (APPJ) technology is to convert a mix of innocuous gases, such as helium and oxygen, into a reactive gas stream capable of detoxifying CBW agents. This is accomplished by passing the feed gas through a plasma (*e.g.*. an ionized gas consisting of ions, electrons and neutrals) where it becomes chemically activated through collisions with energetic electrons. APP decontamination devices may provide a much needed method of CBW decon which, unlike traditional decon methods, is dry and nondestructive to sensitive equipment, such as electronics and irreplaceable objects. This would provide a fast and portable means of restoration of contaminated items for which the only current option is ultimate disposal. These devices would rely heavily on the novel Atmospheric Pressure Plasma Jet (APPJ) technology which has been developed at LANL over the past five years and was a winner of a 1999 R&D 100 Award. APPJ has been shown to kill *Bacillus globigii* (BG) spores, a surrogate for anthrax. Collaborative testing with ECBC has also shown APPJ to neutralize surrogate and actual CW (VX) agents. Several techniques are also being evaluated for use in an APP Decon Jet for decontamination of sensitive equipment and materials that cannot be placed inside a chamber.

This device would be most useful for spot decontamination of interior spaces containing these items such as airplanes, control centers for commercial communications, power and transportation facilities as well as conventional office space. Transition opportunities for this technology include JSSED Blk II/III and the commercial sector in FY03.

Supercritical Carbon Dioxide: DoD CBDP

The objective of this effort is to develop an approach for sensitive equipment decontamination using dense gas phase carbon dioxide. When gaseous carbon dioxide is compressed and heated beyond its critical point, it begins to take on physical properties similar to that of a liquid solvent. By operating above the critical point, the dense gas phase region, changing the pressure and temperature will influence the density and thus solvent power. Phase boundary measurements indicate that the chemical agents HD, GB and VX are highly soluble in carbon dioxide at conditions near the critical point. Recent efforts focused on: (1) dynamic and static tests to define phase boundaries, (2) decontamination efficacy tests using a range of materials (i.e. plastics, elastomers, painted surfaces), (3) material's compatibility tests, (4) adsorption testing as a means to re-circulate liquid carbon dioxide, and (5) bench-scale extractions using chemical agent surrogates. Work on this effort concludes at the end of FY03, although there is interest in this technology within DoD chemical agent demilitarization programs.

Chlorine Dioxide Gas Phase Technology for BW/CW Decon(ClO2): DoD DARPA

This work examines the utility of gas phase chlorine dioxide as a building decontamination agent after a biological or chemical release. It is a component of the DARPA Immune Building Technology Development (TD) effort, initiated in Jan., 2001. Phase I of the effort was a laboratory/modeling feasibility study, phase II a proof-of-principle study, culminating in experiments carried out at full scale. The respirable component of an aerosolized biopathogen release advects with the air, suggesting the utility of a gas phase decon agent - the agent can reach any location accessible to the pathogen, including those which cannot be reached by liquids or foams. The results achieved to date in the program (as well as those in the Hart Building and the Brentwood Post Office facility) have confirmed expectations - chlorine dioxide achieves FDA standards for sterilization (> 6 logs kill against Ba surrogates), with little or no damage to building contents. Ongoing components of the program will investigate biopathogen kill mechanisms, and efficacy against alternate (non-anthrax) pathogens.

Plasma: DoD CBDP

The objective of this effort is to evaluate new plasma technologies for application to sensitive equipment decontamination, specifically vehicle interiors. This is a highly leveraged effort that considered plasma technologies under development at other government agencies (including DOE) as well as in academia and commercial industry. The DoD plasma effort began in FY99 with chemical agent decontamination efficacy studies on the atmospheric plasma jet technology under development at Los Alamos National Labs. Although the outcome of the decon efficacy studies was promising, several technical challenges precluded pursuing plasma approaches at that time. Hence, the plasma efforts at DOE and other commercial and academic facilities were put in a "technology watch" status by DoD. To gauge the recent progress made, DoD is conducting a two-year effort that began in FY02 to assess recent advancements in plasma and related technologies and potentially support the development of promising candidates for use in sensitive equipment decontamination. Technologies selected for assessment with chemical warfare agents include atmospheric uniform glow discharge plasma and a microwave driven plasma jet, both of which use forced air as the carrier and delivery gas. A high frequency Rf generated plasma is also being assessed using CWA and simulants. Singlet oxygen, which is produced in some plasmas, is being assessed using a generator of pure singlet oxygen against

CWA simulants to determine fundamental reaction kinetics and as a potential decontamination device.

Vaporous Hydrogen Peroxide (Buildings): DOE CBNP

As the events of the fall of 2001 have shown, gas-phase decontaminants are necessary for decontamination civilian or urban settings. After gross decontamination of exposed surfaces, less accessible areas such as heating, ventilation and air-conditioning (HVAC) components, associated ductwork, electrical conduits, and cracks and cavities in wall may still require decontamination. Vaporous hydrogen peroxide (VHP) has a high likelihood of success in this application. VHP is highly sporicidal at very low concentrations at ambient temperature and pressure conditions and comparatively low relative humidity, with contact times of less that 1 hour. VHP appears to be significantly less corrosive than other free-radical producing sterilants, and has proved effective against a number of microorganisms, spores, and viruses. A significant advantage of VHP is that it breaks down into water vapor and oxygen. VHP generators are available commercially and have been used to sterilize clean rooms in the pharmaceutical industry.

This work will focus on building HVAC systems, both in the context of decontaminating the HVAC system itself, as well as using the HVAC system to introduce VHP into the building. Working with Steris Corporation, the project will: (1) evaluate the ability of VHP introduced into the room via the HVAC system to decontaminate aerosolized Bacillus spores, (2) determine if spores can be transported into less accessible areas and if VHP introduced via the HVAC system can decontaminate these locations, (3) conduct a survey of commercial building HVAC systems to categorize the variety of systems that may require decontamination, (4) perform an engineering design review to determine how VHP generators could be interfaced with HVAC systems, and (5) demonstrate the use of VHP to decontaminate large office spaces or entire buildings.

Vaporous Hydrogen Peroxide (Vehicles): DOD CBDP

In FY03, Congress appropriated significant funding to study vapor-based decontamination. This is a comprehensive research and development program for improving the chemistry of vapor-based decontamination systems and improving the delivery of these decontaminants. A primary area of interest is vaporized hydrogen peroxide (VHP) technology for use in decontamination of aircraft and other combat vehicle interiors as well as other military hardware. This effort will leverage the demonstrated capabilities of VHP for biological agent decontamination and extend this capability to chemical agent decon.

Dual Phase Decon: DOE CBNP

During studies to evaluate the state of the art in decontamination technology for application to subway systems and other closed and semi-closed structures as part of an on-going DOE study (PROTECT), it became evident that a gap exists in our suite of available decontamination technologies that prevents the effective decontamination of sensitive equipment. Although there are several very effective technologies currently available for the decontamination of large surfaces and structures, these cannot be used on electrical equipment without making that equipment inoperable and useless. The inability to decontaminate this type of equipment without destroying it seriously compromises the ability of any emergency response plan to quickly and effectively restore a system to normal operations. Therefore, the objective of the study is not only to eliminate this critical deficiency, but to advance a decontamination technology which is totally portable; has absolutely no requirement for external reagents, gases or power supplies; is relatively cheap to develop and operate; can be stored for long periods of time without performance decrement; requires little training to operate; and is highly effective toward both chemical and biological agents.

Supporting Technologies

Decontamination/Restoration Methodology: DOE CBNP

The CBNP Decontamination/Restoration Methodology program is focused in two areas: the first area is to investigate required clean-up levels and related regulatory issues, while the second area is centered on improving the technical basis for decontamination/restoration following a WMD event. The primary goal of this effort is to establish a methodology to determine the level of clean-up required to meet both regulatory and stakeholder needs. During FY01, a complete, detailed CW risk assessment was generated. Also, in FY01 ORNL conducted an analysis of lessons learned from previous decontamination experiences. There are considerable number of decontamination experiences that can improve the basis for decontamination and recovery planning. These events have never been documented in a systematic fashion nor examined for the lessons learned. Such documentation is essential to developing effective protocols and providing consistent and valid information to the public on the appropriate procedures for decontamination and other safe protective measures. Case study reports and a final lessons-learned report were completed in FY01.

Solid Phase NMR Analysis Protocol Development: DoD CBDP

The objective of this project is to develop methodologies to study sorption/degradation of agents on solids and in the environment. This will enable the design of advanced reactive sorbents, and further the understanding of agent fates. The project will also identify environmentally stable products.

Mass Decontamination Protocols: TSWG

During FY01, TSWG CBRNC users were focused in two areas: 1) Scientifically validated and consensus-based personnel decontamination procedures for employment with civilian personnel; 2) Management of contaminated animal and plant materials. Mass Decontamination Protocols develops science- and consensus-based best practices for the decontamination of a large number of civilian victims of a biological agent, a toxic industrial chemical, a persistent chemical warfare agent and a non-persistent chemical warfare agent. This project was initiated because military procedures are not well suited for use by the civilian community. International partners are participating in the development of these protocols. Intended users are Public Health Service and Civilian HAZMAT Units. Decontamination guidelines will be published in a handbook for use for the civilian community in Q4FY03. A professional journal article highlighting the findings and recommendations of this study will be published for peer review in Q1FY04.

Decontamination Parametric Analysis: EPA

For various CB agents and building decon approaches (fumigants, liquids, energy-based devices), an experimental parametric analysis will be conducted of decon performance (efficacy, compatibility with building materials/furnishings, residual decon agent on surface) as key parameters are systematically varied (decon agent concentration, exposure time, substrate/carrier, environmental conditions, energy input).

Bio Decon Efficacy Protocols: DoD CBDP

Traditional plate count methods for determination of biological decontamination efficacy are extremely labor and time intensive and have tremendous cost and schedule impacts on the development of new biological decontamination techniques. New rapid efficacy test methods will greatly reduce cost and schedule risks associated with screening new decontaminants. These new methods shall incorporate fluorescence and other spectroscopic techniques to accurately enumerate spores or bacteria. Validation of new methodologies is anticipated by the end of FY 04.

Building Disinfection By Products: TSWG CBRNP

Growing concerns related to future terrorist attacks involving *Bacillus anthracis* (anthrax) and other biological agents have necessitated consideration and implementation of building disinfection. This involves the introduction of a strong disinfecting agent such as chlorine dioxide (ClO_2), ozone (O_3), paraformaldehyde or methyl bromide (CH_3Br) at high gaseous concentrations for extended periods into buildings to destroy the biological agents. While the primary concern associated with building disinfection is effective destruction, a secondary concern not previously addressed is the potential formation of dangerous building disinfection by-products (BDBPs), i.e., chemicals generated mainly as a result of heterogeneous reactions between disinfectants and indoor materials. This project conducts chamber tests using the principal gas phase decontamination reagents acting on a range of common office materials to identify and quantify the disinfectant/material by-products that have adverse acute or chronic toxicities. This project began in Q2FY03 and will deliver the database with the test data results in Q4FY04.

APPENDIX C

Acquisition/Transition Activity Involving Information Systems

The transition and acquisition activities to which information systems research and development programs and DoD and DOE make significant contributions are introduced below.

NARAC Operational Integration: DOE CBNP

The project will develop an operational atmospheric dispersion modeling system, which provides predictions and assessments of the consequences of chemical and biological releases in the urban environment. This project will radically expand NARAC capabilities by incorporating key new chemical and biological (CB) transport-and-fate tools, including infiltration models for residential and commercial buildings (LBNL), advanced source term and dose response models (SNL/ECBC), urban dispersion and rapid response models (LLNL, U.K. Dstl), value-added products (e.g., casualty estimates, affected population, recommended protective actions), and situation awareness analysis tools for field measurement, geographical, and meteorological data. The system will provide plume predictions, affected population maps, casualty estimates, protective action guidelines, and situation-awareness displays to aid federal, state, and local agencies, emergency planners and responders, and public health officials in assessing health risks, recommending emergency actions, and determining appropriate medical treatment.

HPAC Operational Integration: DoD TDO

HPAC models all Nuclear, Biological, and Chemical (NBC) collateral effects of concern to military operations. These may derive from the use of NBCR weapons or from conventional weapon strikes against production and storage facilities for such weapons. Similar effects may result from military or industrial accidents. HPAC provides source information on potential radioactive releases from a nuclear weapon or reactor accident and has the capability to generate source terms for nuclear, chemical and biological weapon strikes or accidental releases. This software tool assists warfighters in weaponeering targets containing weapons of mass destruction (WMD) and in emergency response to hazardous agent release. Its fast running, physics based algorithms enable users to model and predict hazard areas and human collateral effects in minutes. HPAC can also provide probabilistic solutions to the atmospheric transport problem. The Hazard Area feature estimates the weather uncertainty and turbulence effects on possible plume trajectories and areas of hazard impact. It is designed to assess the validity of the prediction and the degree of confidence in your answer.

HPAC is an operation tool designed for a variety of users from front-line troops to emergency response personnel. It also retains the ability for an expert user or analyst to perform high-resolution or customized calculations. Running on a laptop, it is capable of producing fast (approx. 1-10 minutes) and accurate hazard predictions. HPAC provides the capability to accurately predict the effects of hazardous material releases into the atmosphere and its impact on civilian and military populations. The software uses integrated source terms, high-resolution weather forecasts, and particulate transport to model hazard areas produced by any military, terrorist or industrial incidents/accidents.

Source and Fate Reference: DOE CBNP

The consequences of a chem/bio release are strongly affected by the amount of the release. A collection of source term models for different dispersion devices, being developed under a separately listed project, will be compiled and prepared for use in dispersion models to determine exposure, and to support planning and facility protection. These models constitute the

Source Term Encyclopedia (analysis tools) that will be the initial element of the Source Term Dose Response Analysis Toolset (STDR). In later years, this project will provide agent survivability (during dispersion) and environmental decay rates for various agents. Dose response and agent survivability will be incorporated into the STDRAT. A central objective is to get these tools out to the users in a format the users find useful. Identification of and communication with end users is an important first activity.

JWARN: DoD CBDP

Joint Service Warning and Reporting Network (JWARN) is an automated Nuclear, Biological and Chemical (NBC) Information System. JWARN Blk I is essential for integrating the data from NBC detectors and sensors into the Joint Service Command, Control, Communication, Computers and Information and Intelligence (C4I2) systems and networks in the digitized battlefield. JWARN Blk I provides the Joint Forces an analysis and response capability to predict the hazards of hostile NBC attacks or accidents/incidents. JWARN Blk I will also provide the Joint Forces with the operational capability to employ NBC warning technology that will collect, analyze, identify, locate, report and disseminate NBC threat and hazard information. JWARN Blk I is located in command and control centers at the appropriate level defined in Service-specific annexes and employed by NBC defense specialists and other designated personnel. It allows operators to transfer data from and to the actual detector/sensor/network and automatically provide commanders with analyzed data for decisions for disseminating warnings to the lowest echelons on the battlefield. It provides additional data processing, production of plans and reports, and access to specific NBC information to improve the efficiency of NBC personnel assets. Blks II and III are planned to integrate this capability into command and control centers so that it will be a segment on existing and future C4ISR systems, and to integrate the sensor outputs directly and automatically with the NBC warning and reporting tools so that sensor data automatically feeds the information system and so that the C4ISR operator may have direct control of the CBRN sensors.

ECTA (JWARN Interim Blk 2/3): DoD CBDP

Embedded Common Technical Architecture (ECTA) completely meets the JWARN ORD requirements for a fully automated CBRN Information System for vehicles, shelter and ships where data is taken directly from the CBRN sensors to generate warning and reporting information directly to and on the host C4ISR system. ECTA provides the Joint Forces a legacy analysis and response capability to predict the hazards associated with any CBRN event. ECTA is a pre-planned product improvement to the Multi-sensor Integrated Chemical Agency Detector (MICAD) system deployed on the Army's Fox vehicles. As such, the ECTA will take MICAD functions such as control of NBC sensors (which is performed through directly, hard wire connections, operator initiated analysis using legacy tools such as the Vapor Liquid Solid Track (VLSTRACK) and Hazard Prediction and Analysis Capability (HPAC), and automatic generation of NATO standard warning reports using JWARN Blk I software), and imbed the control functionality within the host C4ISR system. Initial target C4ISR systems are the Maneuver Control System (MCS) used by the Army for Fox vehicles, the GCCS-M system used on Navy ships, and the Theater Battle Management Core Systems (TBMCS) used by the Air Force.

Joint Effects Model (JEM): DoD CBDP

JEM is the acquisition program of record that will transition the Science and Technology capabilities of VLSTRACK, HPAC, and D2PC. Once fielded, JEM will be the standard DoD Nuclear, Biological and Chemical (NBC) hazard prediction model. JEM will be capable of modeling hazards in a variety of scenarios including: counterforce, passive defense, accident and/or incident, high altitude releases, urban NBC environments, building interiors, and human performance degradation; some of these capabilities will be included following the release of

Blk I. JEM will support defense against NBC and Toxic Industrial Chemical (TIC)/Toxic Industrial Material (TIM) weapons, devices, and incidents. JEM will be verified, validated, and accredited (VV&A) in accordance with the applicable DoD VV&A directives. When used operationally, JEM will reside on and interface with C4I systems. Warning systems on those C4I systems will use JEM to predict hazard areas and provide warning to U.S. forces within those areas. When used analytically, JEM will assist DoD components to train jointly, develop doctrine and tactics, and assess warfighting, technology, and materiel development proposals, and force structuring. JEM (unclassified version) will also support homeland defense through use by Civil Authorities and Allies.

Joint Operational Effects Federation (JOEF): DoD CBDP

The Joint Operational Effects Federation (JOEF) is one of the Battle Management projects within the Joint Chemical, Biological, Radiological and Nuclear (CBRN) Defense Program. The mission of JOEF is to provide an accredited, predictive multi-level resolution information system to determine and assess the impact of CBRN warfare on military operations. This system will support (1) non-real time advance planning and analysis of wartime operations, (2) near real-time decision-making in wartime operations, (3) operational requirements refinement, and (4) operational inputs to the acquisition process.

JOEF will be developed in four blocks. Block I will provide a modeling and simulation (M&S) analysis capability for assessing CBRN effects on fixed site aerial ports operability and medical requirements. POM 04 includes funding for Block I with Block I IOC scheduled for FY06. Block II will expand the architecture to include seaports and land-based fixed sites and provide capability to link output to theater and campaign level models. Block III will further expand to include mobile land and littoral forces and provide link to manpower, logistics and training planning tools. Block IV will provide a full combat effects model for deliberate and operational planning. All blocks will be compliant with the Common Operating Environment (COE) and with the High Level Architecture (HLA).

Civil Support Information System: DoD CBDP

Operationally, the CSIS will provide a seamless integrated environment for: 1) the technical and procedural means to easily share and assess critical information while maintaining situational awareness, 2) the means to run a user-friendly integrated suite of M&S applications that address the spectrum of the consequence management operations, 3) communicating through a survivable, scalable, deployable, secure and interoperable voice and digital data communications system, 4) rapid access to common authoritative and real-time environmental, terrain, urban, infrastructure, population, medical, and logistics data and resource information, 5) efficient and accurate recording, tracking and reporting of CBRNE events and related support task, and 6) WMD Civil Support operation training, planning and analysis.

Technically, CSIS will provide the link between the different component applications, the communications media, data sources, and other information systems. CSIS will provide this infrastructure by defining a standards-based architecture and providing common services.

High Level Response System: DOE CBNP

It is anticipated that the Biological Defense Architecture may provide a framework for integrating different types of models into higher-level analysis, planning/training, and ultimately response tools for situational awareness and tradeoff analyses across the spectrum of biological threat and preparedness.

WME Battle Lab: DoD TDO

The mission of the WME Battle Lab is to match weapon effects modeling and simulation capabilities with user needs, emphasizing weapons of mass effects. The Battle Lab will have three main focuses: 1) Provide a collaborative WME-focused operations research/analysis and weapons effects modeling and simulation capability to the DoD to assess the effectiveness of operational theater plans, formulate alternatives in mitigating the effects of WME, develop optimal effects-based strategies for the application of combat resources, and support homeland security; 2) utilize a common operational picture and virtual environment to display WME impacts on the battlespace and provide visualization tools to hone operational decision-making through exercise, operational and wargame support, experimentation, analysis, concept exploration/assessment, requirements determination/assessment and training; and 3) prototype, demonstrate, evaluate and distribute applied technology products and operational capabilities in support of DoD and federal organizations tasked to conduct WME consequence assessment and management.

Virtual Prototyping System (VPS): DoD CBDP

The VPS will provide the immersive capability to evaluate how the operating characteristics of proposed or developmental CBDE will affect the performance of the overall system. VPS will enable materiel developers to assess how proposed CB defense systems will provide increased capabilities. At a more detailed level it will allow system designers to assess the impact that design changes have on the overall system performance. The virtual immersive capability will enable human factors evaluations of operator interfaces long before the first prototype units of the developmental CBDE are built in hardware. All of these capabilities address the basic Simulation Bases Acquisition tenet of enabling early and sustained user feedback throughout the system design process. Performance assessments and evaluation will be enabled at the engagement and engineering levels of simulations. The trade space for evaluating technical options for system and component alternatives will be expanded. That evaluation will take place in a realistic synthetic or virtual environment. Human and live system in-the-loop capability will exist. Development will be based on current proof-of-concepts simulation used to support developmental, analysis, training and testing efforts. The envisioned simulations system will be able to operate at specific sites for focused evaluations or distributed to many sites for robust Joint Task Force (JTF) engagement assessments of engineering alternatives.

CBRN Training & Simulation Capability (TSC): DoD CBDP

The TSC will provide the ability to simulate NBC attacks using NBC assets and C4I2SR systems for training and exercises. It will allow for exercise planning, execution, and capturing lessons learned for after action review (AAR). It will provide the capability to use or simulate the use of NBC sensors, Tactical Engagement Simulation (TES) gear, and simulators for training and exercises. The TSC will provide the capability to simulate NBC environments under live, virtual, and constructive simulations. It will provide the capability to use training and simulations in both Command Post Exercise (CPX) and Field Training Exercise (FTX) environments. It will operate in conjunction with the Joint Warning and Reporting Network (JWARN), future Joint NBC Battle Management systems, and the other Modeling and Simulations capabilities developed to support NBC defense requirements. The TSC will be used at all levels of NBC defense decision-making to train for and simulate NBC attacks against friendly forces. It will provide for the training and use of simulation capability by all NBC defense personnel and commanders related to NBC threats and scenarios. When fully fielded, the TSC will run the gamut from individual/team trainers up through large unit battle staff training capabilities.

Demonstration Programs

RestOps ACTD: DoD CBDP

The Restoration of Operations Advanced Concept Technology Demonstration (ACTD) will demonstrate those actions taken before, during and after an attack to protect against and immediately react to the consequences of a CB attack. These actions aim to restore operating tempo (OPTEMPO) in the execution of the mission and in the movement of individuals and materiel to support combat operations at a fixed site. One goal of this ACTD is to generate improved chemical and biological warfare detection technologies in an effort to reduce vulnerabilities at a fixed site. Candidate technologies will be tested during Joint Chemical Field Trial testing at DPG and subsequently down-selected for further testing during the ACTD. The ACTD is currently scheduled for the Final Demonstration to occur in FY03, which will be followed by two years of residual support at Osan Airbase.

Contamination Avoidance at Seaports of Debarkation (CASPOD): DoD CBDP

Seaports of debarkation (SPODs) are recognized as critical assets for power projection and force deployment operations, making them attractive targets for exploitation. Unified Combatant Commanders have responsibility to defend SPODs against terrorist or other adversary CB, Toxic Industrial Chemical (TIC), or Toxic Industrial Material (TIM) attacks/releases. The CASPOD ACTD will leverage work done in other projects (Seaport Protection Analysis (SPPA) project and the RestOps ACTD) to identify and provide technologies, capabilities, and procedures that can be utilized prior to, during and after an attack/release to mitigate effects on time phased force deployment data (TPFDD) flow. Operational concepts and TPPs to initiate and sustain CB and TIC/TIM defense operations at SPODs will be demonstrated. The force structure necessary to implement procedural and equipment requirements will be identified and refined. A resident/pre-positioned or rapidly transportable CB and TIC/TIM defense equipment and material packages needed for employment at SPODs will be developed and demonstrated. Strategic operational improvements/shortfalls for CASPOD contingencies will be identified. In addition, a forum, process and structure for addressing and modifying U.S., coalition and host nation policy issues will be provided. The ACTD demonstration phase is currently scheduled for FY02-04, with transition occurring in FY05-06.

LINC: DOE CBNP

The objective of the Local Integration of NARAC with Cities (LINC) project is to demonstrate the capability for providing local government agencies with advanced CBNP-developed operational atmospheric plume prediction capabilities that can be seamlessly integrated with appropriate state and federal agency support for homeland security. LINC's approach is to integrate National Atmospheric Release Advisory Center (NARAC) capabilities with local emergency management and response centers. NARAC is a state-of-the-science plume modeling and geographical information system, as well as a expert resource center. NARAC provides operational support for emergency planning, real-time assessment, and detailed studies of incidents involving a wide variety of hazardous releases to the atmosphere, and has be utilized for decades by the federal government.

For a chemical, biological, or radiological release, NARAC will provide emergency managers and responders (fire, police, HAZMAT, etc.) accurate information on the extent and effects of the airborne material to guide decisions regarding protective actions to be taken (evacuation, sheltering in place, etc.), critical facilities that may be at risk (hospitals, schools, etc.), and safe locations for incident command post siting. In addition, NARAC provides tools for response teams from multiple jurisdictions (local, state, and federal) to effectively share information regarding the areas and populations at risk.

The LINC program is working intensively with a handful of cities—with varying geography, size and emergency management resources—to integrate NARAC tools and services and demonstrate operational use. This integration effort includes configuring and integrating advanced plume modeling software, real-time local weather data access, geographical information integration, user training and exercises, support for emergencies, and development of information sharing across local, state, and federal agencies. The ultimate goal is a nationwide system that integrates NARAC tools and services with the appropriate local, state and federal agencies. Complementary plume modeling tools developed by other agencies, and in widespread use nationally, will be integrated with NARAC tools as part of the LINC program. Based on the experiences with the pilot cities and work with other agencies, the LINC program will develop technical and financial plans for long-term operational support of a nationwide LINC-NARAC system.

Test/Validation Programs

Joint Field Trials/Laboratory Tests/TRE: DoD CBDP

The purpose of the testing programs is to evaluate new and existing technologies for incorporation into biological defense programs. This roadmap includes the testing of several technologies. Successful technologies are subsequently matured for integration. The program timeline initiates in FY98 and has no termination.

Water Channel Dispersion Experiment: DoD TD

Description not available at time of printing

URBAN 2000: DOE CBNP

Tracer and meteorological experiments were conducted in Salt Lake City in October 2000 that provide a unique set of night-time atmospheric dispersion data covering transport scales from individual buildings on through the urban scale to the regional scale. This research collaborated closely with DOE's Environmental Meteorology Program by adding a downtown-scale URBAN experiment to their planned multi-million dollar urban- to regional-scale Vertical Transport and Mixing experiments (VTMX) in Salt Lake City. Meteorological and fluid dynamical processes governing dispersion in downtown Salt Lake City were investigated in this research. These results also provide guidance in the design of other CBNSP model validation and verification experiments. The goal of the URBAN field experiment was to obtain data for model validation from a new case study of building-scale (1-10 km) to urban-scale (10 –100 km) diffusion designed to fill knowledge gaps in the available database. This research has contributed significantly by providing field data to model developers for testing and improving, and to begin verifying the hierarchy of atmospheric models used to simulate the dispersal of CB agents in the atmosphere. Guidance in the design of final model validation and verification experiments has also resulted from this research.

Urban Experiment (Intermediate Scale): DoD TD

Modeling the dispersal of an agent in an urban environment is an important but very difficult endeavor. The urban dispersal model development will progress from low-resolution components now undergoing V&V, to higher-fidelity components expected to be available in 2-3 years. The experiment demonstrated use of urban dispersion approaches during the 2002 Olympics, including the Urban Dispersion Model (UDM), the Urban Wind Module (UWM), and a combination of UDM with UWM. The UDM model is currently integrated with the SCIPUFF transport and dispersion model in HPAC. Only limited validation of the model algorithms was accomplished. FY03 tasks include development of next-generation urban models to include the integration of an interior building model, continued maturing of existing urban model technologies (UDM and UWM), and tighter integration of urban models into planning tools. In

FY03, urban model components will be validated to the point that they may be incorporated formally into a released version of HPAC.

Indoor Dispersion Experiment: DoD TD

Description not available at time of printing

Joint Urban 2003: DoD/DOE

The goal of this three-year project is to conduct extensive urban field studies in collaboration with other agencies to provide documented and quality assured data sets for evaluating and improving urban indoor and outdoor dispersion models, and to advance the understanding of the physical processes governing atmospheric dispersion. The quality-assured data sets are essential for establishing confidence that atmospheric models used to simulate dispersal of potential toxic agents in urban atmospheres are giving trustworthy results. These models will be used by personnel in intelligence, law enforcement and emergency management to adequately plan for, train for and respond to potential terrorist attacks.

Planning was underway in FY2002 by DTRA and CBNP researchers for the Joint Urban 2003 field study to be held in Oklahoma City, Oklahoma during July 2003. URBAN 2000 investigated the nighttime boundary layer during relatively light-wind conditions, whereas Joint Urban 2003 will investigate the daytime (with some nighttime studies) fully-turbulent urban boundary layer during moderate wind conditions. The combination of data from URBAN 2000 and the planned Joint Urban 2003 field study will allow urban dispersion models to be evaluated over the broad range of atmospheric conditions and the full range of atmospheric motions that are important in responding to potential releases of toxic agents in urban areas. Indoor tracer infiltration experiments will also be conducted during Joint Urban 2003 to provide data for evaluating and improving indoor dispersion models and the coupling of outdoor models to indoor models.

Guidance Programs

Areas for Capability Enhancement (ACEs): DoD CBDP

The ACEs are established by the Counterproliferation Program Review Committee (CPRC). The ACEs were established to characterize those areas where progress is needed to enhance both the warfighting capabilities of the Combatant Commanders (COCOMS) and the overall ability to satisfy the demands of U.S. counterproliferation policy. A detailed discussion of each ACE along with agencies' programs to support each ACE can be found in the 2003 CPRC Report on Activities and Programs for Countering Proliferation and NBC Terrorism. The ACEs provide broad guidelines for R&D/acquisition investment and prioritizes areas where additional capabilities are required to meet the challenges posed by WMD proliferation threats. There is one ACE that addresses prediction and warning of CBW agents (DoD ACE Priority 2: Detection, Identification, Characterization, Location, Prediction and Warning of CW and BW agents); these Information Systems programs support that ACE. The ACE's timeline is unlimited.

Joint Future Operational Capabilities (JFOC): DoD CBDP

JFOC was established by the Joint Service Integration Group in an effort to identify and prioritize Joint User far-term future operational capabilities as expressed in the emerging Joint NBC Defense Concept. The overall intent is to provide enhanced user guidance to the Joint NBC Defense Science and Technology (S&T) community to assist in the NBC S&T program formulation and execution process. Prioritized Joint Future Operational Capabilities include:

- Contamination Avoidance
- NBC Battle Management

- Individual Protection
- Restoration Capability[9]
- Collective Protection

A detailed description of JFOC can be found in the NBC Defense Annual Report. The JFOC timeline is unlimited.

Research and Development Programs

Infrastructure Design & Protection

Immune Building Toolkit (IBTK) Design Tool: DoD DARPA

The Immune Building Toolkit (IBTK) is one component of the Immune Building Program being developed by the DARPA Special Projects Office. The objective of the Immune Building program is to make military buildings (such as barracks, office buildings, and command and control centers) far less attractive targets for attack by airborne/aerosolized chemical or biological warfare agents (CWA, BWA) by modifying and augmenting building infrastructure to greatly reduce the effectiveness of any such attack. The program has three goals: to protect the human inhabitants of such buildings in the event of an attack; to restore the building to full function as quickly as possible after the attack; and to preserve forensic evidence for treatment and retaliation. The Immune Building Toolkit will be a modeling and planning tool for assessing the effectiveness of various potential building protection strategies and systems architectures, determining the optimal protective solution, and estimating the overall protection. IBTK will focus on the challenging problem of protection from internal agent releases. Infrastructure modifications and augmentations may include changes to the ordinary HVAC (heating, ventilation, air conditioning) infrastructure - including a real-time active control of airflow patterns and/or full-time passive highly efficient filtration–in addition to whatever other modifications might be appropriate, such as real-time neutralization of an aerosolized agent or networked surveillance systems. IBTK will provide an estimate of the protection level for a given building design. IBTK is meant for use by building designers but may also be useful to structural engineers, professional vulnerability assessors, and force protection planners.

Urban Biodefense Studies: DOE CBNP

This study examines how technology can be more effectively employed to significantly reduce casualties resulting from biological attacks against US cities. The three main objectives of this program are to: develop and evaluate defense architectures; identify and assess cost-effective, high-leverage technologies for population protection, and develop strategies to support city, state, and national objectives for defense against, and response to an urban BW attack. A model-based tool called Master Timeline Curves was developed to evaluate performance and feasibility of various architectures.

Source Term

Source Term Definition: DOE CBNP

The consequences of a chem/bio release are strongly affected by the amount of the release. This program is fundamental to determining realistic and credible source terms for chem/bio releases. A collection of source term models for different dispersion devices is being developed for dispersion models to determine exposure. These models will also support planning and facility protection. This project will provide experimentally based models describing the aerosol and vapor release of chemical and biological agents from a variety of improvised dispersion devices (not military munitions) and from re-release of deposited material. These models will be integrated into the Source Term reference, listed separately.

[9] Decontamination is included within the JFOC definition of Restoration Capability.

Source-driven Calculation of Unknown Source Terms: DOE CBNP

This project is developing source reconstruction modeling tools for accidental or terrorist chemical or biological releases. The tools will provide quantitative estimates of the release location, time, and quantity, based on data from available sensor networks. Bayesian-inference stochastic sampling algorithms will be developed, which determine the distribution and likelihood of possible source terms, consistent with the observed data, measurement accuracy, and model error. Rapid quantitative source term reconstruction is needed in order to produce the best possible predictions of agent transport and the resulting health risks to the exposed population and emergency responders.

Source Characterization Database: DoD CBDP

The overall objective is to develop a source characterization database of CB agent delivery systems as part of M&S tools available to the operational CB community and in direct support to the HPAC program. A tool called CARREM has been developed to estimate a delivery system's initial source, in parameters needed by transport and diffusion models. Subject matter experts will evaluate the validity of these estimated parameters. When there is no consensus in the validity of the parameters or the experimental methods used to obtain them, a community accepted value will be determined. In cases where there is a significant disagreement in a value and no clear indicator that is the more valid, the parameters will be identified as an estimate used pending further experimentation or investigation.

Exterior Transport

VLSTRACK

Vapor, Liquid, and Solid Tracking (VLSTRACK) is the DoD interim standard for simulating hazards from CB weapon attacks (i.e. counter proliferation passive defense applications). VLSTRACK uses gaussian puffs to model CB releases and track the resultant hazard downwind for a wide range of chemical and biological agents and munitions of military interest. VLSTRACK is included in a number of larger CB software systems, including the Consequence Assessment Tool Set (CATS). VLSTRACK, through CATS, is intended to be used by first responders. CATS assesses the consequences of technological and natural disasters to population, resources and infrastructure. Developed under the guidance of the US Defense Threat Reduction Agency (DTRA) and the US Federal Emergency Management Agency (FEMA), CATS provides significant assistance in emergency managers' training, exercises, contingency planning, logistical planning and calculating requirements for humanitarian aid.

D2Puff: DoD CBDP

D2-Puff is a transport and diffusion model that predicts potential hazards involving accidental releases of chemical warfare agents in the U.S. Army's stockpile and non-stockpile programs. The model is used in the planning and response phases of potential accidents. D2-Puff is used to support funding decisions by the Army and Federal Emergency Management Agency (FEMA) to enhance safety in the local civilian communities, including location of planning zones, sirens, tone alert radios, and collective protection facilities. Automated links allow direct input of on-site meteorological data, continuous updating of projected hazard areas, and rapid communication of model results to County and State Emergency Management Agencies. D2-Puff version 4.0 is a kinematic gaussian puff model that accounts for spatial and temporal variability in a wind field over complex terrain. D2-Puff is currently installed at five stockpile sites and is scheduled for installation at the three remaining sites in CY02. The U.S. Army Safety Office has accredited the D2 model for all applications; D2-Puff has full accreditation at three sites and partial accreditation at two other sites. An Independent Verification & Validation was performed on both models in 1999. Training is provided on-site periodically. Model development is funded

by the U.S. Army SBCCOM Program Manager for the Chemical Stockpile Emergency Preparedness Program.

Urban Dispersion Model (UK): DoD TDO

Modeling the dispersal of an agent in an urban environment is an important but very difficult endeavor. The urban dispersal model development will progress from low-resolution components now undergoing V&V, to higher-fidelity components expected to be available in 2-3 years. The experiment demonstrated use of urban dispersion approaches during the 2002 Olympics, including the Urban Dispersion Model (UDM), the Urban Wind Module (UWM), and a combination of UDM with UWM. The UDM model is currently integrated with the SCIPUFF transport and dispersion model in HPAC. Only limited validation of the model algorithms was accomplished. FY03 tasks include development of next-generation urban models to include the integration of an interior building model, continued maturing of existing urban model technologies (UDM and UWM), and tighter integration of urban models into planning tools. In FY03, urban model components will be validated to the point that they may be incorporated formally into a released version of HPAC.

CT Analyst: DoD TDO

CT-Analyst is a model for rapidly calculating hazard areas following point source releases in specific urban locations. CT-Analyst is easy to use (an hour or two of training/practice) and yet captures 80 to 90% of the fidelity of full 3D CFD computations. This is well suited for training exercises and system optimization. It supports instantaneous situation assessment, backtracks to unknown source locations from immediate sensor fusion of qualitative reports and quantitative data, and projects evacuation routes to minimize personnel exposure. Developed by the Naval Research Laboratory, Laboratory for Computational Physics and Fluid Dynamics (NRL/LCP) for the Missile Defense Agency (MDA), the model's speed is based on creating and mining a data structure developed from computational fluid dynamic runs for a well-defined urban topographic model. However, only city-size areas (several kilometers on a side) are practical at high resolution (~meters). Lower-resolution representations up to 50 km on a side have been developed and demonstrated with full functionality

An integration of CT-Analyst with PEGEM is underway that will allow a user to model releases from missiles as well as from point source that can encompass both large and small-scale events. This integration of the two models will produce a synergistic capability, i.e., allow for enhanced modeling capability that exceeds the individual capabilities of the two models. PEGEM will not be just a front end for CT-Analyst; rather PEGEM will use its defined scenario description (meteorology, source term description and location) and larger area/altitude coverage, taking advantage of CT-Analyst's higher resolution, city-specific topography where applicable.

Chemical Warfare Naval Simulation- Deposition and Weathering of a Chemical Attack on a Naval Vessel (CWNAVSIM-DAWN): DoD CBDP

CWNAVSIM- DAWN is one module of the CWNAVSIM model. The model was developed to address specific naval acquisition program decisions regarding chemical weapons defensive systems, specifically the Tactics, Techniques, and Procedures (TTP) needed to defend the ship and the placement of detection devices. DAWN simulates Gaussian puff vapor and liquid clouds (primary cloud) interacting with the ship's external surfaces. Currently, the DAWN module is being replaced with CBW-CFX code.

MESO

MESO is a Lagrangian particle random-walk transport and diffusion computer code that provides approximate downwind hazard predictions for a wide range of chemical and biological

agents and munitions. The computer software simulates releases of CB agents and tracks the particles downwind using state-of-the-art meteorology, while accounting for the physical processes that affect the agent. While the ultimate purpose of this tool is to provide protection of troops, other purposes include providing realistic simulations to evaluate type and location of sensors, requirements for protective gear, troop dispersions, collateral effects, etc. Because Lagrangian particle trace methods are used, the model can be linked to a flow field model for use in the urban environment.

Operational Building-Urban-Regional Modeling: DOE CBNP

The project will develop a validated state-of-the-science multi-scale atmospheric modeling suite, which will support homeland security needs for predictions of the consequences of chemical and biological (CB) releases in the urban environment. The models to be developed and validated are core models of DOE/NNSA's operational National Atmospheric Release Advisory Center at LLNL. The models cover a broad range of spatial and temporal scales and incorporate either parameterizations or explicit physical process algorithms, as appropriate for the scale of the simulation and the information desired.

Fast Response Urban Transport & Dispersion: DOE CBNP

A fast running urban atmospheric plume transport and dispersion model is needed for many aspects of preparation, training, assessment, and response in case of a terrorist CB incident in a city. There are also many applications that require reasonable accuracy and many repetitions of simulation to be performed, such as vulnerability assessments, training and tabletop exercises, and event reconstruction. The QWIC modeling system consists of quick-running codes, a wind model (QWIC-URB) that produces 3D wind fields around building complexes and a dispersion model (QWIC-PLUME) that utilizes the wind fields and produces 3D concentration fields, wrapped in a graphical user interface (QWIC-GUI). The modeling package is intended for transport and dispersion problems around individual buildings, through several city blocks, and up to the larger city scale. The ultimate goal is to produce a validated fast-running urban modeling system that can be used in operational settings as a standalone tool. It will be the underlying engine in several CB agent toolkits (e.g., a Sensor Siting Tool).

Urban Model: DoD TD

Description not available at time of printing

HPAC: DoD CBDP

Hazard Prediction and Assessment Capability (HPAC) is a nuclear, chemical, biological hazard prediction system that predicts hazards resulting from the use of our forces on opposition facilities of assets. It is the only model accredited to the Department of Defense for this purpose. HPAC version 4.0 is a modular system of capabilities using a Gaussian puff methodology transport and dispersion engine called SCIPUFF to drive specific nuclear, biological or chemical event applications. It has a broad database system and is able to use various weather data inputs. HPAC supports operational decisions, operational contingency planning, hazard assessment doctrine, acquisition program studies, and requirements generation. HPAC version 4.0 is currently available and fielded directly from the Technology Development program conducted by the Defense Threat Reduction Agency (DTRA). Training is also available from the developer. During FY03, this technology is being transitioned to the Joint Effects Model (JEM) Acquisition Program.

Computational Fluid Dynamics for Chemical and Biological Defense (CBW-CFX): DoD CBDP

CBW-CFX uses computational fluid dynamics code to model the transport, diffusion, deposition, and surface evaporation of chemical and biological agents in and around 3-D structures. CFX is a commercial code developed by AEA Technologies, which allows licensed users to develop subroutines which can be used within the code. CBW-CFX adds methodology for physical processes unique to chemical and biological agents. CBW-CFX is intended for use by researchers. To extend its utility, it has been interfaced with other models such as VLSTRACK and the Ventilation Model (VENM).

Interior Transport

Building Interiors: DOE CBNP

Under this project, development proceeded of the super-COMIS model, to describe the behavior of both gas and particle-phase contaminants, along with improving submodels for air flows in duct systems and in stairwells. Laboratory experiments and CFD modeling established the basis for model development and will be used to evaluate the submodels. Field experiments were conducted to study aerosol penetration into buildings and to examine the vertical exchange of air in multi-story buildings through stairwells and elevator shafts. The field experiments differ from the lab experiments in the scale of experiment and in the use of real buildings. Third, COMIS and eventually the Super-COMIS have been used for simulation of the transport and fate of contaminants in prototypical buildings. The prototypical buildings represent a range of building categories, and the modeling will provide estimates of mixing times, concentrations and exposures to chem/bio materials. Finally, rules of thumb for building managers and first responders have been developed and posted online, and are periodically updated. Current work in this area focuses on transitioning developed capabilities into the NARAC suite.

Building Interior Transport: DoD TD

Description not available at time of printing

Chemical Warfare Naval Simulation- Ship Chemical Warfare Ventilation Model (CWNAVSIM-VENM): DoD CBDP

CWNAVSIM- VENM is one module of the CWNAVSIM model. The model was developed to address specific Naval acquisition program decisions regarding chemical weapons defensive systems, specifically the Tactics, Techniques, and Procedures (TTP) needed to defend the ship and the placement of detection devices. VENM traces the vapor movement internally, keeping track of concentrations and dosages in each compartment using a zonal module.

Agent Fate

Reactivity: DOE CBNP

Currently the fate of chemical and biological agents inside buildings is not well understood. Identification of problematic classes of building materials will greatly simplify sampling and decontamination efforts. This project will provide the needed physical basis for modeling levels of residual agent as a result of natural attenuation and active decontamination procedures. The effort includes detailed examination of the physical and chemical interactions between agents and a suite of contaminated materials, and development and experimental verification of suitable models of the sink/re-suspension terms for use in dispersion models. The objective of this project is to develop, refine, and verify physically based models for predicting the long-term fate of chemical agents following release. A plan to implement these models in higher level codes such as NARAC, a Source Term reference, etc. will be jointly developed with the owners of those codes.

Resuspension of Agent and Secondary Transport: DOE CBNP

The goal of this work is to determine experimentally parameters describing sorption/desorption, tracking and resuspension of suitable chemical and biological agent surrogates. These parameters can be used to improve models of agent transport and fate within buildings which enable a variety of users to better predict exposures to chemical or biological agents under a variety of release or protection scenarios.

These parameters will be used in the SuperCOMIS model, the integration of residential models with NARAC and the new model devised for anthrax dispersion in a building (Anth-Trax). Results from these studies will permit parameterization of both tracking and resuspension as a function of particle size for inclusion in transport and fate models. This work will examine the behavior of chemical agent surrogates in laboratory chambers using various surface materials and develop the appropriate sorbtion/desorption parameters for use directly in the fate and transport models and in models to estimate surface contamination for decontamination responses. The Anth-Trax simulation program, which incorporates tracking and resuspension of particles due to human activity, will incorporate the results of these experiments.

Agent Fate and Effect Predictive Modeling: DoD CBDP

This project supports the QDR Transformation Operational Goal to Protect Bases of Operation. It will develop a validated chemical threat agent fate model that is a capable of accurately predicting the persistence of hazard (both contact and inhalation) due to chemical warfare agent dispersed on surface materials relevant to fixed site operational scenarios. The timeframe for this project is FY03-05. The results will be transitioned to JEM.

Consequence Management

PEGEM: DoD MDA

The Post Engagement Ground Effects Model (PEGEM) is an expert system toolbox used in the analysis of ground effects caused by the intercept (of operationally deployed) chemical, biological, high explosive or radiological weapons or agents distributed in bulk, canister, or bomblet submunition payloads by many threat platforms. PEGEM connects payload lethality in the air with casualties on the ground. PEGEM provides CBW and high explosive (HE) munition hazards, as well as agent-coated solid debris field assessment in the form of effects on the ground against user-definable assets. Output of the model is in the form of CBW or HE agent and debris coverage, as well as resulting estimated casualties at user-specified times of interest (TOIs). Development of PEGEM supports Ballistic Missile (BM) system acquisitions, and provides a valuable consequence management tool to evaluate individual and integrated BM systems and estimate/simulate CBW effects on the battlefield. PEGEM capabilities are designed primarily for hit-to-kill (HTK) interceptor technology for acquisition, but also contain blast/fragment interceptor capability.

NBCR Simulator: DoD CBDP

The NCBR Simulator provides the capability to utilize existing hazard transport and dispersion codes within the context of detailed materiel evaluations. NCBR enables high fidelity simulations of CB defense equipment (CBDE) such as detectors and protective gear to "see" and react to CB hazards within a detailed synthetic environment. In real time, the NCBR calculates a high fidelity, three-dimensional (3D) hazard environment as a function of hazard delivery system (source term), meteorological conditions and complex (3D) terrain. The DTRA SCIPUFF and the Naval Surface Warfare Center's VLSTRACK Gaussian puff models provide the means for the NCBR to calculate CBR hazard environments. The NCBR makes the data available to other simulations via full 3D representations of the environments (instantaneous air concentration), 2D grids (dose, deposition, and air concentration contours), and at a point via a subscription process.

SBCCOM serves as the proponent for configuration control and release of the NCBR, and DTRA WMD Analysis and Assessment Center supported the migration of the tool to the DoD's High Level Architecture (HLA) standard for distributed simulation. NCBR is a key enabling technology for the more inclusive Virtual Prototyping System and will provide the mobile forces capability to JOEF.

To address nuclear environments, the NCBR uses DTRA's External Blast (XBLAST) and Version 6 of Atmospheric Transport of Radiation (ATRv6) as the means for calculating the blast and prompt radiation environments resulting from tactical nuclear warheads. The NCBR publishes axis-symmetric 2D grids and 1D (line) arrays that the receiving simulation rotates about the origin of symmetry to obtain a full 2D or 3D environment.

Dose Response Curves: DOE CBNP

A methodology for deriving dose response parameters for a general population from data for a healthy population has been established. A healthy population is roughly one third of the general population. The military population is also considered to be similar to the healthy population. Estimates have been made for nerve agents for the general population for two and ten minute exposures. Work will continue to develop dose response curve models applicable to the general population and will include other agents.

Chemical Warfare Naval Simulation- Naval Unit Resiliency Analysis (CWNAVSIM-NURA): DoD CBDP

CWNAVSIM- NURA is one module of the CWNAVSIM model. The model was developed to address specific Naval acquisition program decisions regarding chemical weapons defensive systems, specifically the Tactics, Techniques, and Procedures (TTP) needed to defend the ship and the placement of detection devices. NURA provided casualty assessments and ship's mission degradation. NURA was developed primarily from the Army's AURA code.

STAFFS: DoD CBDP

Simulation Training and Analysis For Fixed Sites (STAFFS) is a general purpose model which represents the operations of large fixed-site facilities such as air bases, aerial ports of debarkation (APODs) and seaports of debarkations (SPODs), with the capability to represent chemical and biological warfare (CBW) attacks and their effects on operations. STAFFS utilizes spatial and temporal CB challenge data calculated by other standard CB hazard assessment models including VLSTRACK and HPAC. CB equipment and agent effects represented in high resolution include detectors, protective gear, decontamination, toxic and infective agent effects, collective protection, medical treatment, equipment induced thermal effects, equipment induced encumbrance, and doctrinal procedures such as work-rest cycles. These effects are represented by engineering level sub-models which can be easily changed to represent different equipment capabilities and levels of ability. Basic operational tasks are modeled using a task-network approach that is adaptable to any desired level of resolution. No other capability currently exists within DoD to assess the operational impact of CBW attacks on critical fixed-site targets. STAFFS is currently in use and being further developed in two major functional areas: 1) support of wargaming and operational exercises including distributed interactive environments, and 2) support of operational and requirements analysis. STAFFS is developed by AFRL.

EpiSims/EpiCast: DOE CBNP

The intent of EpiSIMS is to couple state-of-the-art population mobility, provided by TRANSIMS, with model viruses and model viral immune systems. This coupling is intended to provide an understanding of the interaction between the biological and social factors contributing to epidemic spread. With this level of detail, one can conduct simulation experiments to test

intervention strategies toward reducing epidemic threat. The EpiSims project provides the basis for current work in EpiCAST. Considerable effort in recent years has gone into developing capabilities for biosurveillance, with the goal of early detection of disease outbreaks caused by biothreat pathogens. Biosurveillance will not cease once an event has been identified, but will continue to provide information to responders. An integrated computational architecture is required that will interact with ongoing biosurveillance in response mode, to provide real-time management guidance. The goal of this project is to produce and validate an integrated architecture for a decision-support tool that will enable near-term, real time epidemiological forecasting during an ongoing event caused by an outbreak (natural or man-made) of a infectious (natural or man-made) pathogen. A pilot study will be conducted in FY04 to gather data for validation of the models at the core of this tool.

Forward Deployed CB Hazard Prediction: DoD CBDP

This task will enhance and accelerate the incorporation of Joint Service Chemical/Biological Defense Modeling and Simulation capability into a state-of-the-art environmental Nowcast meteorological system. The enhanced Nowcast system will provide forward-deployed land- and sea-based units with an organic capability to continuously update a local web-enabled JWARN (Joint Warning and Reporting Network) simulation using the latest available on-scene meteorological information. Nowcast provides the on-scene meteorological information by fusing the latest observation data (surface, upper air, aircraft, satellite, and radar) with objective analyses and short-range mesoscale weather predictions to maintain a time-varying, high-resolution, three-dimensional database of the environment. The environmental database is then sampled to provide the input wind, density, cloud, terrain, and precipitation fields for the Hazard Prediction and Assessment (HPAC) and Vapor, Liquid, Solid Tracking (VLSTRACK) models in JWARN. The user interface will be a simple JAVA applet with pull-down folders to fully describe a simulated chemical or biological attack. JWARN will then run automatically when the database is updated through Nowcast. Output graphics of dosage concentration, three-dimensional plume visualizations, and hazard animations will automatically be displayed on a local web site.

Scenarios and Methodologies for Military Worth: DoD CBDP

The objective of this effort is to formulate detailed technical vignettes and data sets to assess a CB defense system on the component level using detailed measures for system performance. The mapping in detail of the interrelation between component features, the system features and operational impact is the major product. As a product it will be an enabler for the Virtual Prototyping System (VPS). This continuation builds on scenarios and methods, and it measures work previously performed in this project. The intent is to have a standing set of detailed operationally relevant, technical vignettes to be used in the VPS to assess, evaluate and test 1) Design alternatives for a specific system on the component level and 2) System options for a given CB Defense Capability. The data sets quantify the features in a simulation. A mature VPS will be able to carry the assessment capability into the systems of systems in the Joint battlespace for CB Defense. The end-state for this task is a compilation of scenarios, methodologies, measures, and detailed technical vignettes for a specific class of developmental materiel systems.

CBDP Integrated Digital Environment (LEAPS): DoD CBDP

The LEAPS (Leading Edge Architecture Prototyping System) capability was initially developed to encourage the widest spread of ship-related information and eases the exchange and availability of information for scientists and engineers performing collaborative studies such as analysis of alternatives (AOA) and systems engineering assessments. This capability facilitates integration of software across multiple disciplines, including mission requirements, ship design, engineering, costing, and warfare analysis. LEAPS implements an integrated virtual prototyping

process for ship concept assessments, similar to that developed for tank concept assessments by the Army Tank-Automotive Command (TACOM). The system is being extended to support chemical and biological defense related needs by becoming the central, standardized repository for meteorological data, ship/building structural data, structural interior and exterior flowfield data, hazard prediction outputs, and population distribution databases. Through the use of LEAPS a standardized approach to model integration is being achieved that will allow for free flow of data between models and will enable the modelers to produce the highest quality model output.

Bio Defense Architecture: DOE CBNP

There is a clear need for tools that manage and organize information and provide decision support for Weapons of Mass Destruction (WMD) events. The Biological Defense Architecture (BDA) will deliver a distributed, interactive simulation capability to synthesize disparate information and models for earlier recognition and improved decision-making in the event of a biological attack. The architecture will synthesize disparate information and models for earlier recognition and improved decision-making in the event of a biological attack. The architecture will simulate biological threat scenarios and include user feedback and control so that a user's decision inputs can impact the scenario. The BDA will be the foundation for an integrated system model for biocountermeasures defense and response that can be applied towards (1) evaluating alternative architectures and modeling tools to guide technology development and planning, (2) performing trade-off and sensitivity analyses to guide WMD preparedness, and (3) developing concepts of operations for decision makers through simulated events with realistic information, pressure, and decisions.

Epidemiology Applications: DOE CBNP

Building on the work to be done in EpiCAST and in dose response, it is anticipated that additional bioterror-related epidemiological tools will be developed.

Supporting Technologies

Center for Special Weapons Effects, NBC Threats, Technology Transfer and Resources (CNTTR): DoD TDO

The CNTTR gives warfighters round-the-clock access to DTRA analytical capabilities and databases in a single WMD technology transfer center. They have immediate access to a collaborative computing capability for real-time WMD event monitoring at multiple fixed and mobile locations. Existing websites on both the NIPRNet and SIPRNet provide an interactive capability for threat modeling and real-time video streaming from incident sites to decision makers. This web-based system has supported a number of high profile events like the Olympics, the G-8 and NATO Summits, Presidential Inaugurations as well as exercises and wargames like TOPOFF, Navy's Global wargames, and Ulchi Focus Lens. In addition, the CNTTR is repeatedly exercised in support of real world missions. The system is being enhanced to include a comprehensive database of chemical and biological weapons information under development in partnership with the United Kingdom's Defence Science and Technology Laboratory at Porton Down. This data will be incorporated into a knowledge-based information repository with adaptive cataloguing (metadata) and search capabilities. Other enhancements will include development of an adaptive intrusion detection system, as well as user-friendly encryption.

Evaluation Methodologies: DOE CBNP

The primary project goal is to develop and deliver a comprehensive methodology for evaluating the next generation of urban transport and dispersion models being developed by the CBNP M&P thrust area. This methodology shall include a scientific review component as well as a statistical model evaluation component, and shall be delivered as a straightforward set of

software and users guide along with test cases. A key element is testing the evaluation procedures on a variety of models that exhibit great differences in sophistication, data requirements, and computational demands. The measures that might be chosen to characterize the performance of simple models may not be appropriate to characterize the performance of more sophisticated models that can potentially provide a more complete description of the relevant physics. Model acceptance criteria shall be suggested. The results of this project will include a set of standardized procedures for evaluating DOE CBNP models. This should allow a more level playing field for comparisons and more easily-understandable results for both model developers and managers.

Urban Topography Databases: DoD/DOE

The goal of this task is to produce the urban databases and parameters required by urban transport and dispersion models, the CB-NARAC modeling system, and the other toolsets. Existing urban databases have significant gaps in both quantity and quality that may limit the efficacy of CBNP modeling efforts. This project will address the shortcomings of existing urban databases while also creating new urban databases, which will improve CBNP analyses and results. There are three major components to this task. First, researchers will statistically characterize urban building morphology as a function of land use. This product will improve the performance of the CBNP suite of atmospheric transport and dispersion models. Secondly, an automated procedure is being be produced to create a new generation urban land use database superior to existing national land use databases. This database will be specifically tailored for the CBNP transport and dispersion models. And third, researchers will construct a day/night urban population database, which will improve the population dosage and casualty estimates for daytime scenarios by accounting for diurnal temporal fluctuations in population demographics. This project will be tightly coupled with the NARAC Operational Integration task area, providing information that is required by and formatted for the CB-NARAC atmospheric transport and dispersion models.

Assimilation Networking and Fusion: DoD CBDP

This task investigates the feasibility of improving NBC situational awareness by fusing non-CB and CB sensor data. Data fusion concepts will be developed to exploit disparate sensor data and incorporate it into the CB decision process. The merits of data fusion concepts using modeling and simulation will be investigated. Information from acoustic, seismic and infrared sensors will be characterized to determine their potential use in supporting enhanced CB situational awareness.

Model Validation Database: DoD CBDP

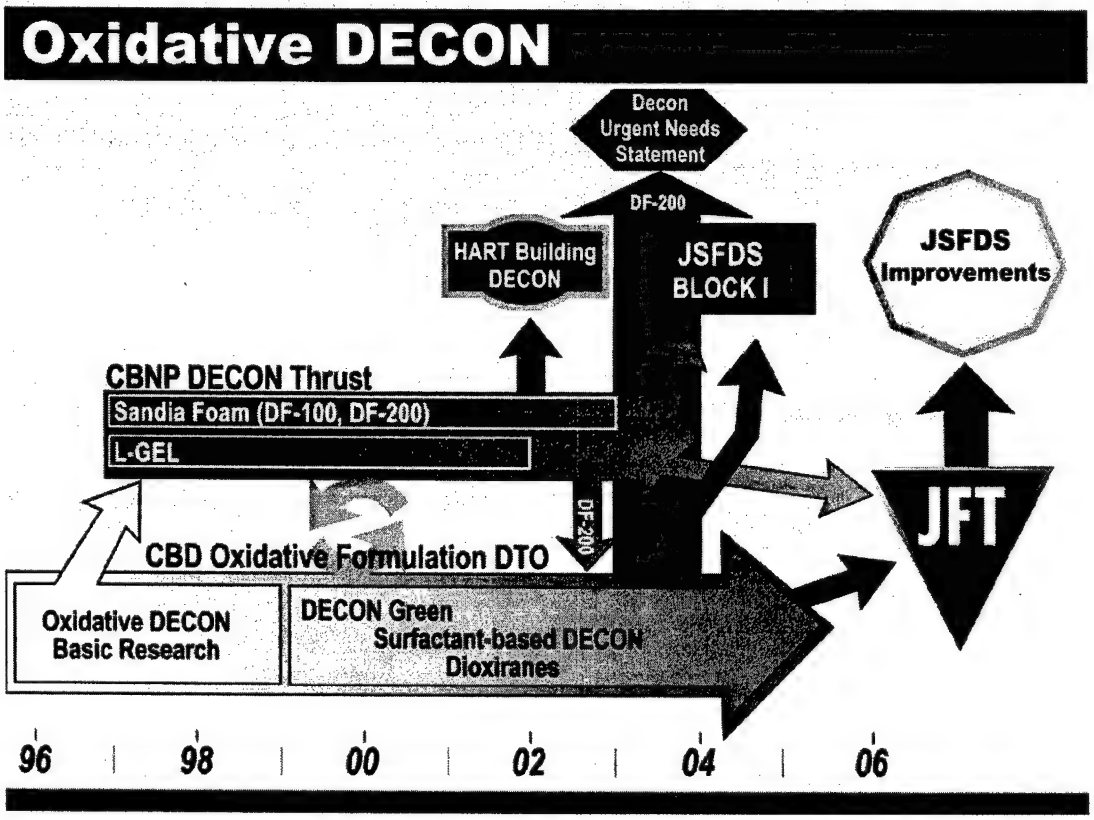
Each of the three DoD standard models (VLSTRACK, HPAC, and D2PCw) has been validated against field trial data. The source terms, meteorological conditions, and contamination levels will be collected from the field trial reports and the files used for model validation. All relevant information will be put into an Oracle database. Additional literature searches of DTIC and Technical Libraries will be performed for field trial reports containing data for contaminant releases in open areas that can be used for model validation. The data will be extracted from these reports and added to the validation database in the same fashion as the original set of reports. Further literature searches will be done to locate reports containing data on the flow of contaminants around buildings and to collect data characterizing the behavior of chemical or biological agents under conditions representative of high altitudes. This additional data will be added to the validation database for use in validating the complex flow and missile intercept capabilities of JEM Blocks 2 and 3.

APPENDIX D

Integration Example: Decontamination Using Peroxy-Based Oxidative Chemistry Approaches II

Oxidative chemical approaches form the basis of the solution chemistry thrust effort of both the Department of Defense and Department of Energy decontamination programs. As such, DoD and DOE have a number of efforts in oxidative chemistry that are at various stages of development. This appendix provides background on the state of peroxy-based oxidative chemistry research within these two agencies, as it applies to the development of solution phase chemical and biological warfare decontaminants. It then describes each of the efforts conducted under these programs, the interrelatedness of the two programs, and the steps taken toward maximizing leverage among the programs and preventing duplication of efforts. Figure 9 shows DoD and DOE past and planned oxidative chemical decontamination program integration efforts.

Figure 11. Integration of Oxidative DECON Efforts.



Background

Various oxidative solutions such as hydrogen peroxide, peroxyacids and potassium peroxymonosulfate have been used for years in disinfecting biological warfare agents. Although investigators had considered these types of oxidative methods over the years for decontaminating chemical warfare agents, it wasn't until the early 1990's that DoD began to realize the full potential of these and other oxidative approaches. Early basic research on peroxy-based

approaches conducted at the Edgewood Chemical Biological Center (ECBC) set the stage for several successful decontamination programs in both DoD and DOE.

Oxidative chemical approaches are very attractive for use as decontaminants for several reasons, which include:

- Their efficacy toward both chemical and biological agents,
- Their considerably lower toxicity than traditional chemical agent decontaminants,
- The relatively environmentally benign nature of the oxidative decontamination solutions, and
- The formation of less toxic, more manageable reaction products during the process.

For example, hydrogen peroxide decontaminates the nerve agent VX, yielding reaction products of low toxicity. This chemical agent is particularly difficult to decontaminate since many of the potential products from reactions with VX yield substances that are extremely toxic. Failure to cleave the P–S bond that occurs with some nucleophilic decontamination processes yields EA2192, a relatively persistent product, the toxicity of which approaches that of some of the G-series nerve agents. Decontamination using hydrogen peroxide, however, rapidly breaks the P–S bond in VX and yields more manageable reaction products.

DoD Oxidative Chemistry Efforts

The oxidative chemical decontamination approaches described in this section are funded and managed as part of the Joint Science and Technology Panel for Chemical and Biological Defense (JSTPCBD) Tech Base Research Program. In order to coordinate efforts within this area, the JSTPCBD Business Area Manager for Decontamination established the Defense Technology Objective (DTO) 44, Oxidative Formulation. The objective of DTO 44 is to develop a non-corrosive, material compatible, non-toxic and environmentally friendly oxidative CB decontaminant to replace the current military decontaminants, DS2 and STB/HTH. Currently there are three oxidative decontaminants under development in DTO CB.44: Decon Green, Dioxiranes, and the Surfactant-Based Decontaminating Solution. In addition to the peroxy-based decon efforts in CB.44, there are several promising technologies funded through Congressional plus-ups that are monitored by the JSTPCBD. All of these developmental decontaminants are described below.

Decon Green

In 1997 after extensive basic research on peroxide solutions as decontaminants, ECBC scientists pointed out that a peroxide-based solution containing co-solvents is a potential broad-spectrum decontaminant for HD, VX and G agents. Furthermore, such decontaminants would avoid the formation of toxic by-products created using chlorine bleach formulations. ECBC, continuing its research on peroxide-based solutions, has now created Decon Green, a sophisticated peroxide-based solution that is as effective as DS2, but does not have hazardous side effects. This solution was designed specifically to meet military needs.

Decon Green combines hydrogen peroxide with a co-solvent and catalyst to provide an effective broad based organic decontaminant effective against chemical and biological warfare agents. Another distinct advantage of this decontaminant is that it will not freeze at subzero temperatures (meets the current –31°C low temperature requirement), nor will its effectiveness decrease due to high temperatures (up to 49°C).

Surfactant-Based Decontaminating Solution

Another promising effort under development in the Decontamination Tech Base Program is the Surfactant-Based Decontaminating Solution that combines a microemulsion with an oxidative peracid solution. Formulations combining a microemulsion with the peracid precursor have demonstrated great potential for chemical and biological agent decontamination. Peracids are known to possess high disinfectant activity against endospore forming bacteria, vegetative cells and viruses. Microemulsions afford a means of dissolving the organic chemical agents and inorganic, reactive decontaminating components in one solution, without the need for environmentally unfriendly solvents.

The peracid precursor offers a unique means of incorporating into the decontamination solution an environmentally friendly, strong oxidizer that is reactive at a mild pH (noncorrosive to materials). The peracid eventually breaks down into a weak acid and water. There are many forms of the peracid precursor, used in the laundry industry, with varying solubility and surface active properties. Although not as far along as Decon Green in its development cycle, initial efficacy results for the Surfactant-Based Decontaminating Solution on chemical and biological agents appear very promising.

Dioxiranes

Dioxiranes constitute a new class of powerful oxidants, first prepared in 1979, by reaction of caroate with a ketone. Since that time, dioxiranes, mainly dimethyl dioxirane (DMDO), have been used extensively as powerful oxidants capable of carrying out a variety of synthetically useful oxidations under mild conditions. To date, the dioxirane effort has shown these oxidants to be very effective against biological agents and a so-far limited set of chemical warfare simulants.

Vapor-Based Decontamination Congressional Plus-Up:

In FY03, Congress appropriated significant funding to study vapor-based decontamination. This is a comprehensive research and development program for improving the chemistry of vapor-based decontamination systems and improving the delivery of these decontaminants. A primary area of interest within the congressional plus-ups is vaporized hydrogen peroxide (VHP) technology for use in decontamination of aircraft and other combat vehicle interiors as well as other military hardware. This effort will leverage the demonstrated capabilities of VHP for biological agent decontamination and extend this capability to chemical agent decon.

DOE Oxidative Chemistry Efforts

The DOE oxidative products described in this section were developed with funding provided by the U.S. Department of Energy's and National Nuclear Security Administration's Chemical and Biological National Security Program (CBNP). Within the CBNP program was the Decontamination and Restoration Initiative that attempted to develop rapid, effective and safe decontamination technologies for the restoration of civilian facilities in the event of a domestic terrorist attack. Development of these technologies focused on three scenarios: open air, semi-enclosed and enclosed facilities. In addition, the needs for these technologies focused on two general areas, decontamination capabilities for the first responder and facility restoration or remediation.

DF–100/200

Under the CBNP charter and leveraging the early basic research efforts in peroxy-based decontamination conducted at ECBC in the early to mid 1990's, the Sandia National Laboratory began development of DF–100 in 1997. DF–100 is an aqueous foam-based decontamination

product that uses hydrogen peroxide as its active component and combines surfactants, carbonates and various foam components to yield a very effective aqueous based decontaminant. The oxidative nature of DF–100 yields desirable reaction products. Recent testing by DoD at both ECBC and Dugway Proving Grounds indicates that the product is effective for neutralizing both chemical and biological agents and also works on a number of anticipated material surfaces.

Although DF–100 was developed under the CBNP program for domestic scenarios, it has great potential for use in military decontamination operations. As such, DoD has considered this product for a number of military applications including the Joint Service Family of Decon Systems Program, the Restoration of Operations (RestOps) Advanced Concept Technology Demonstration (ACTD) and the Contamination Avoidance for Seaports of Debarkation (CASPOD) ACTD.

In 2001, SNL completed an upgrade of DF–100, called DF–200, that improved the product's efficacy on chemical and biological agents and addressed some of the concerns raised by DoD in using DF–100 in a military scenario. To assist in the development of DF–200 for use in military operations, the JSTPCBD funded a two-year effort under the CB3 Technology Transfer program beginning in 2002. Work is currently under way at both Sandia National Labs and ECBC and is being coordinated by the JSTPCBD's Business Area Manager for Decontamination.

L–gel

In a parallel effort under the CBNP program, Lawrence Livermore National Labs (LLNL) began production of a gel-based oxidative decontaminant, L–gel, that uses "Oxone," a commercial preparation of potassium peroxymonosulfate as its active component. Previous research at ECBC demonstrated the effectiveness of oxone in decontaminating VX and mustard agents. Unfortunately the efficacy of oxone on G-type agents was slow under normal conditions. LLNL incorporated a fumed silica gelling agent into the oxone solution. The fumed silica gave the solution its characteristic "gel-like" property, but it also catalyzed the hydrolysis of G-agents, giving a broad-spectrum chemical efficacy to the product. Recent advances in the product include the development of a "solid water" aerosolized form of the liquid decontaminant, making it deliverable to ductwork and other confined spaces.

Vaporized Hydrogen Peroxide (VHP)

Vaporous hydrogen peroxide (VHP) appears to show great potential for the decontamination of biological agents in the interiors of buildings. VHP is highly sporicidal at very low concentrations at ambient temperature and pressure conditions and comparatively low relative humidity, with contact times of less that 1 hour. VHP appears to be significantly less corrosive than other free-radical producing sterilants, and has proved effective against a number of microorganisms, spores, and viruses. A significant advantage of VHP is that it breaks down into water vapor and oxygen. VHP generators are available commercially and have been used to sterilize clean rooms in the pharmaceutical industry.

This work focuses on building HVAC systems, both in the context of decontaminating the HVAC system itself, as well as using the HVAC system to introduce VHP into the building. Working with Steris Corporation, the project will: (1) evaluate the ability of VHP introduced into the room via the HVAC system to decontaminate aerosolized Bacillus spores, (2) determine if spores can be transported into less accessible areas and if VHP introduced via the HVAC system can decontaminate these locations, (3) conduct a survey of commercial building HVAC systems to categorize the variety of systems that may require decontamination, (4) perform an engineering

design review to determine how VHP generators could be interfaced with HVAC systems, and (5) demonstrate the use of VHP to decontaminate large office spaces or entire buildings.

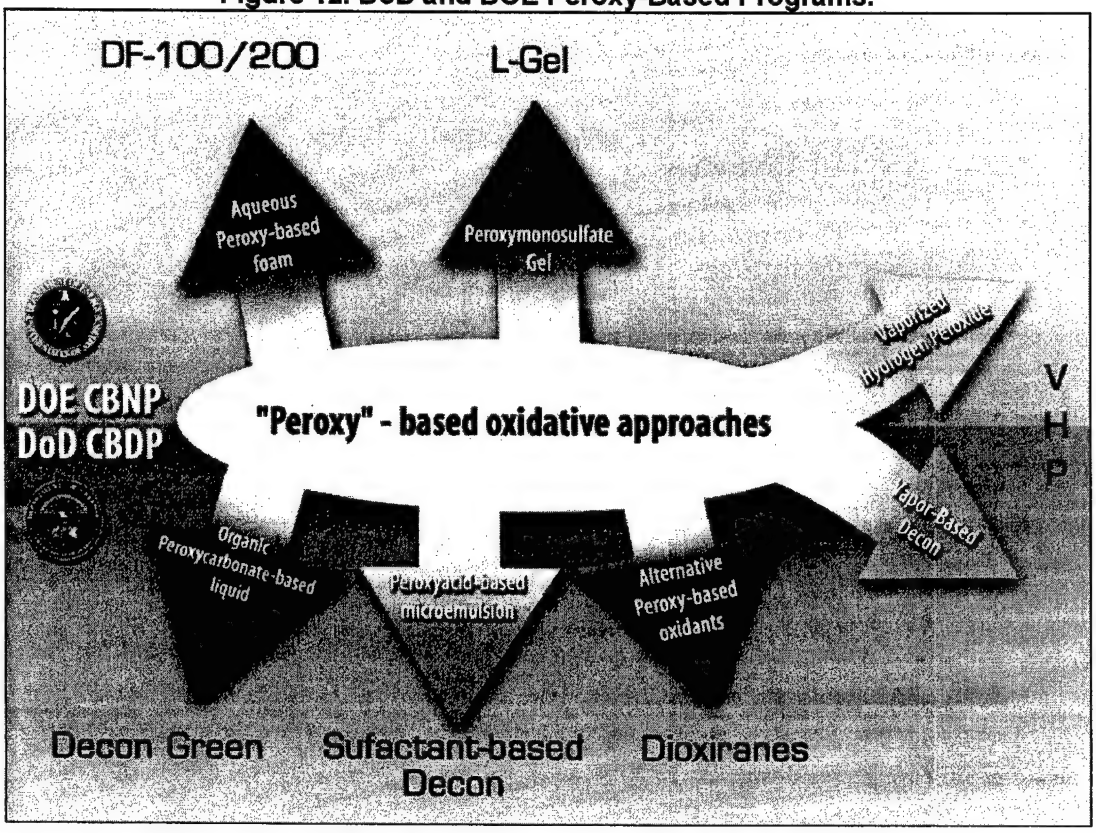
Development of Cooperative Effort

Development of decontamination solutions that are based on oxidative chemistry approaches clearly exemplifies the close interaction between DoD and DOE decontamination development programs. Figure 10 shows how the DoD and DOE solution phase oxidative chemistry programs focus on a central approach of incorporating peroxy-containing species as the active component in their decontamination solutions. Although the peroxy approach is a common thread amongst the developmental programs, Figure 9 shows that the final product and overall approach employed by each individual development program is vastly different. This common thread allows the various investigators to maximize leveraging opportunities while minimizing redundancy among the projects.

It is important to remember that although the projects shown on Figure 10 use a similar active ingredient, they are producing vastly different products, each with its own particular characteristics. For example, DF–100/200 and Decon Green both use hydrogen peroxide as the active component, but their base formulations are drastically different. The DF–100/200 products are aqueous-based solutions that can be concentrated and later mixed with water onsite to provide the decontaminant. This characteristic is particularly beneficial from a logistical and application standpoint, but some sacrifices are made because many chemical agents and thickeners are organic compounds and not very soluble in aqueous solutions. The degree to which the product is soluble is critical from the standpoint of decontamination efficacy, since one of the primary factors that dictates efficacy is the solubility of the chemical agent in the decontaminant. Decon Green on the other hand is an organic solution; chemical agents and thickeners are very soluble in this solution. The organic nature of Decon Green, however, makes concentration difficult, which can be problematic for both logistics and the application.

The other products shown on Figure 10 are unique variants of the "peroxy" oxidative approach, each approaching the problem of chemical and biological decontamination in a slightly different manner. At this stage of development, it is difficult to say which peroxy-based approach will be the best, or even if a single "best approach" exists.

Figure 12. DoD and DOE Peroxy-Based Programs.



The two-year DF–200 CB3 Technology Transition effort described earlier further exemplifies the close interaction amongst DoD and DOE. The Department of Energy initially leveraged basic research done by DoD and developed an effective product for a domestic response scenario. The Department of Defense recognized the potential of DF–200 and provided recommendations on ways to improve the product to meet military requirements and ultimately incorporated advanced development and testing efforts into its 6.3 level program. These efforts will not only provide an improved product for DOE to use in domestic response scenarios, it will provide DoD with an effective aqueous-based oxidative decontamination solution.

As cited earlier, there has been a great deal of leveraging between DoD and DOE on the oxidative chemistry program. The principal investigators (PIs) have jointly attended multiple meetings, workshops and symposia on these projects. Of particular note are the 2000 New Concepts in Decontamination Workshop co-sponsored by the JSTPCBD and the Army Research Office and the annual DOE CBNP Summer Meetings. To ensure leveraging continues in this area, the JSTPCBD Business Area Manager is serving as a liaison between DOE researchers and the PI's working on the DoD funded efforts. This formalized coordination will minimize the potential for organizational conflicts of interest and will ensure that, when appropriate, DOE technologies have a link to DoD decontamination activities. In the case of DF–200, this coordination has been very successful. Thus, such collaborative efforts will continue whenever appropriate opportunities exist.

The newest area of collaboration between DoD and DOE is with the use of vaporized hydrogen peroxide as a chemical and biological agent decontaminant. Although these are separate efforts within the two departments and will be used in different scenarios, DoD and DOE

are each aware of the goals and objectives of the other program, and leveraging opportunities have been identified. Close cooperation is planned at the program and research levels in a manner similar to that seen with the other peroxy-based programs. In addition, the EPA is interested in collaborating and leveraging since VHP was identified as a potential restoration technology within the EPA Safe Building Program.

Use of DF–100 in Response to the October 2001 Anthrax Incidents

DF–100 was used to help remediate office buildings both on Capitol Hill and in New York City which were contaminated as a result of the anthrax incidents of late 2001. Immediately after the Hart Senate Office building became contaminated, DF–100 (supplied by Envirofoam Technologies, Inc.) was evaluated in government-sponsored tests against live, vaccine-strain anthrax spores at Johns Hopkins Advanced Physics Laboratory. Also included in the tests was bleach (as a control) and the NanoBio, Inc. Nanoemulsion formulation. Since DF–100 outperformed both bleach and the Nanoemulsion formulation in these tests, it was selected to remediate selected areas of the Capitol Hill office buildings. Over the next few weeks, DF–100 successfully remediated a large mailroom facility in the Ford House Office Building, a large mailroom in the Dirksen Senate Office Building, and selected hallways, stairways and a freight building in the Hart Senate Office Building. Post-sampling indicated complete kill of anthrax spores and surrogate spores placed for verification purposes. There was minimal collateral damage in the first application (the Ford mailroom) due to overapplication of the foam as a result of operator inexperience. No collateral damage was noted in the second and third applications (in the Dirksen and Hart Buildings).

DF–100 (supplied by Modec, Inc.) was also used to successfully remediate the ABC News Building and New York Post Building in New York City. In this case, DF–100 was applied as a fog using commercial off-the-shelf cold fogging units. Post-sampling indicated successful kill of the anthrax spores. No negative health effects have been noted in either building.

Selection of DF-200 as an Interim Decontaminant for Use by DoD

In late FY02, U.S. Central Command issued an Operational Needs Statement (ONS) for an interim decontaminant to replace the currently fielded general purpose military decontaminant, DS-2. The DoD Joint Requirements Office reviewed and validated the need for an interim decontaminant and issued an Urgent Needs Statement (UNS) in September 2002. Using the results from the 6.3 Technology Transition testing and a variety of other test data, the JSTPCBD Business Area Manager conducted a risk assessment of commercially available decontaminants and recommended DF-200 as the lowest risk technical option for meeting the CENTCOM requirements.

In 4QFY02, DoD began rapid developmental and operational testing of DF-200 in its liquid configuration. This testing defined the operational capabilities of DF-200 and allowed interim fielding of the product to deployed forces for use under defined conditions. Follow-on testing in 2QFY03 evaluated the efficacy of DF-200 when delivered using specialty applicator systems for equipment and wide-area decontamination operations.

Throughout the UNS testing of DF-200, DoD worked very closely with Sandia Labs to better understand the capabilities of the product and further develop the capabilities of DF-200. The previous working relationships between DoD and DOE greatly improved communication during this testing effort and ultimately contributed to the rapid fielding of an interim decontaminant prior to hostilities beginning in the CENTCOM area of operations.

Conclusion

Oxidative chemical approaches are very attractive for use as decontaminants for a variety of reasons. Researchers at both the Department of Defense and the Department of Energy have succeeded in advancing this technology to the point where the efficacy of oxidative decontaminants exceeds that of currently fielded decontamination products. Through programs such as the DoD CB3 Technology Transfer Program and the continual interaction of DoD and DOE scientists, it is reasonable to assume that a permanent oxidative replacement of DS2 and STB/HTH for use in military chemical and biological warfare agent decontamination operations will be achieved in the very near future.

The timeliness of this research and development could not be clearer. In the aftermath of the October 2001 anthrax incidents, several facilities required decontamination, a daunting task under any circumstance. Likewise, events in the Middle East and concerns with the state of currently fielded military decontaminants underscored the need for the urgent replacement of DS-2 for military operations. Both of these events were made easier as a result of this cooperative investment in decontamination research and development.

APPENDIX E

Congressional Language Calling for the Integration Effort

Senate Armed Services Committee Language, S. Rpt. 106–50 S. 1059

"In 1996, the CPRC recommended that the Department of Defense and the Department of Energy establish an integrated research, development, and acquisition plan for technologies associated with chemical and biological counterproliferation. To date, there has been no visible result of this CPRC recommendation. The committee directs the Under Secretary of Defense for Acquisition and Technology to submit the integrated plan to the congressional defense committees, not later than March 1, 2000."

Senate Armed Services Committee Language Requiring a Report on CPRC Integration with Domestic Response Users

"In 1996, Congress added a mission to the CPRC charter requiring efforts to '...negate paramilitary and terrorist threats involving weapons of mass destruction.' Given this responsibility, and the resources and expertise available to the CPRC, the committee believes that the CPRC should consider establishing a mechanism for working with the domestic response program to help ensure that the research, development, and acquisition of equipment for domestic response to weapons of mass destruction has appropriate involvement from the user community. The committee directs the CPRC to provide a report to the congressional defense committees, not later than March 15, 2000, on this recommendation and its potential benefit to the domestic response program."

APPENDIX F

List of Acronyms

ACEs	Areas for Capability Enhancements
ACTD	Advanced Concept Technology Demonstration
AIDET	Aircraft Interior Detector
AMB	Advanced Multifunction Biochip
APDS	Autonomous Pathogen Detector System
ATD	Advanced Technology Demonstrations
BAM	Business Area Manager
BASIS	Biological Aerosol Sentry and Information System
BCAS	Biological Combat Assessment System
BSPS	Bio Sample Prep System
BW	Biological Warfare
BWD	Biological Warfare Defense program
CADB	Chemical Agent Detection Badges
CASPOD	Contamination Avoidance for Seaports of Debarkation
CBD	Chemical and Biological Defense
CBDP	Chemical and Biological Defense Program
CBNP	Chemical and Biological National Security Program
CBRNC	Chemical, Biological, Radiological and Nuclear Countermeasures
CCAS	Chemical Combat Assessment System
CDC	Center for Disease Control
CENTCOM	Central Command
COCOM	Combatant Commander
CP	Counterproliferation Program
CPRC	Counterproliferation Program Review Committee
CRP	Critical Reagents Program
CWICS	Chemical Warfare Interior Component System
DARPA	Defense Advanced Research Projects Agency
DCAS	Domestic Chemical Assessment System
DDAP	Domestic Demonstration and Acquisition Program
DI&W	Detection, Identification and Warning
DNA	Deoxyribonucleic Acid
DoD	Department of Defense
DOE	Department of Energy
DF–100/200	Decontamination Foam–100/200
DPG	Dugway Proving Ground
DTRA	Defense Threat Reduction Agency
ECBC	Edgewood Chemical Biological Center
ELISA	Enzyme Linked Immunosorbent Assay
EMD	Engineering and Manufacturing Development
EPA	Environmental Protection Agency
ESI	Electrospray Ionization
FDA	Force Differentiation Assay
GFE	Government Furnished Equipment
HANAA	Handheld Advanced Nucleic Acid Analyzer
HPLC	High Performance Liquid Chromatography
IC	Intelligence Community

ICDS	Improved Chemical Detection System
IOT&E	Initial Operational Test and Evaluation
ISD	Individual Soldier Detection
IVD	Individual Vapor Detector
JBPDS	Joint Biological Point Detection System
JCAD	Joint Chemical Agent Detector
JCBAWM	Joint Chemical Biological Agent Water Monitor program
JFOCs	Joint Future Operational Capabilities
JFT	Joint Field Trials
JHU–APL	Johns Hopkins University Applied Physics Laboratory
JMCBD	Joint Modular Chemical and Biological Detector
JPO–BD	Joint Program Office–Biological Defense
JPSSNS	Joint Portal Shield Sensor Network System
JSSED	Joint Service Sensitive Equipment Decontamination
JSTPCBD	Joint Science and Technology Panel for Chemical and Biological Defense
LANL	Los Alamos National Laboratory
LFADD	Large Frame Aircraft Decontamination Demonstration
LLNL	Lawrence Livermore National Laboratory
LRIP	Low Rate Initial Production
MAGIChip	Micro Array of Gel Immobilized Compounds on a Chip
MALDI	Matrix-Assisted Laser Desorption Ionization
MASINT	Measurement and Signature Intelligence
NBC	Nuclear, Biological and Chemical
NPAC TWG	Nonproliferation and Arms Control Technology Working Group
OPTEMPO	Operating Tempo
ORNL	Oak Ridge National Laboratory
PACOM	Pacific Command
PEO-CBD	Program Executive Office(r) for Chemical and Biological Defense
PCR	Polymerase Chain Reaction
PI	Principal Investigator
PM	Program Manager
POM	Program Objective Memorandum
PROTECT	Program for Response Options and Technology Enhancements for Chemical/Biological Terrorism
PY–GC/IMS	Pyrolysis–Gas Chromatography/ Ion Mobility Spectrometry
R&D	Research and Development
RDA	Research, Development and Acquisition
RDT&E	Research, Development, Test and Evaluation
RestOps	Restoration of Operations
S&T	Science and Technology
SCAMP	Shipboard Chemical Agent Monitor Portable
SESI	Science and Engineering Services Incorporated
SNL	Sandia National Laboratory
SOFCAS	Special Operations Force Chemical Agent Detector
TOF	Time of Flight
TSWG	Technical Support Working Group
UCP	Up-Converting Phosphor
UCPFCM	Up-Converting Phosphor Flow Cytometer
UCPHHA	Up-Converting Phosphor Handheld Assay
USAMRIID	U.S. Army Medical Research Institute of Infectious Diseases